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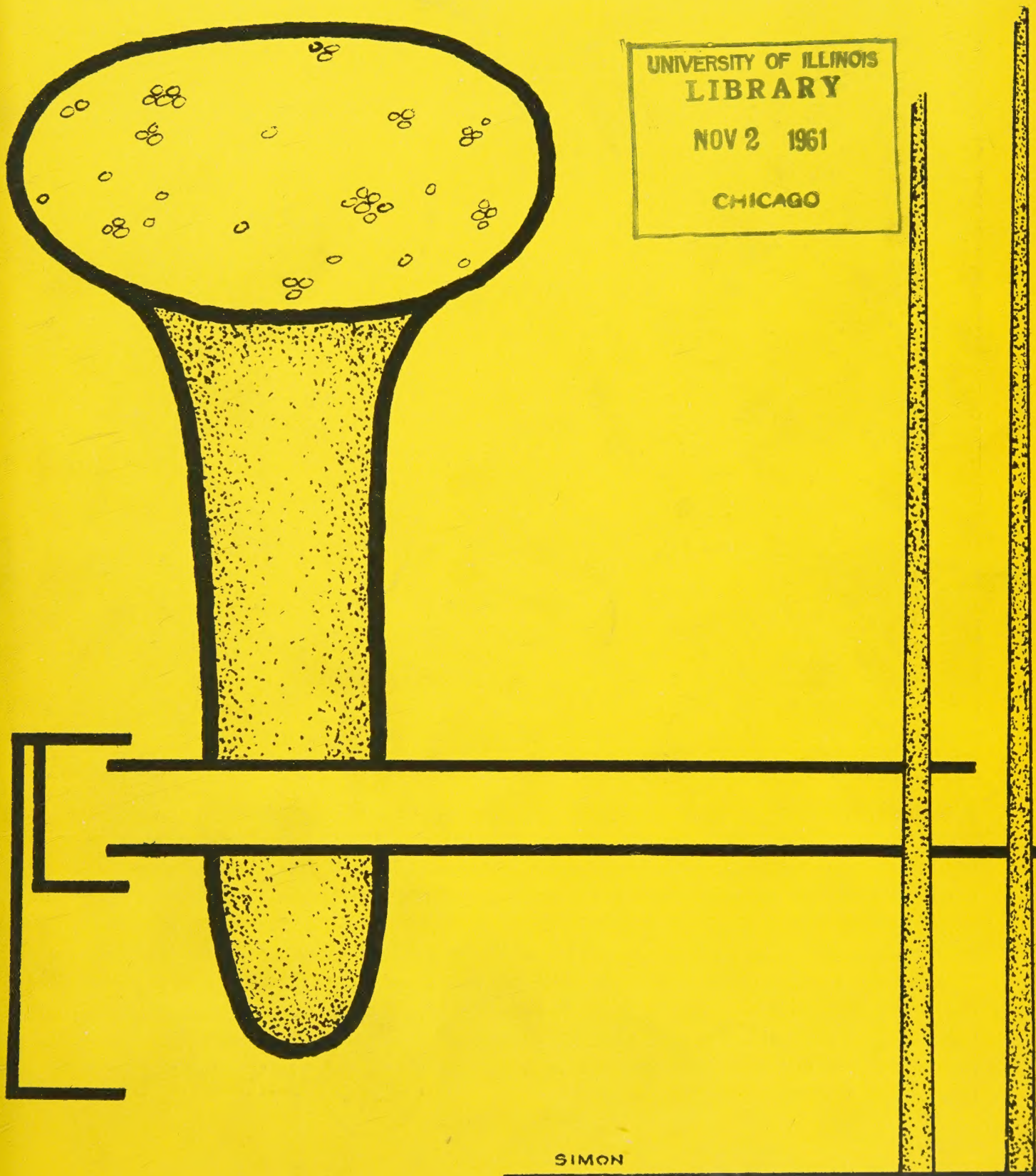

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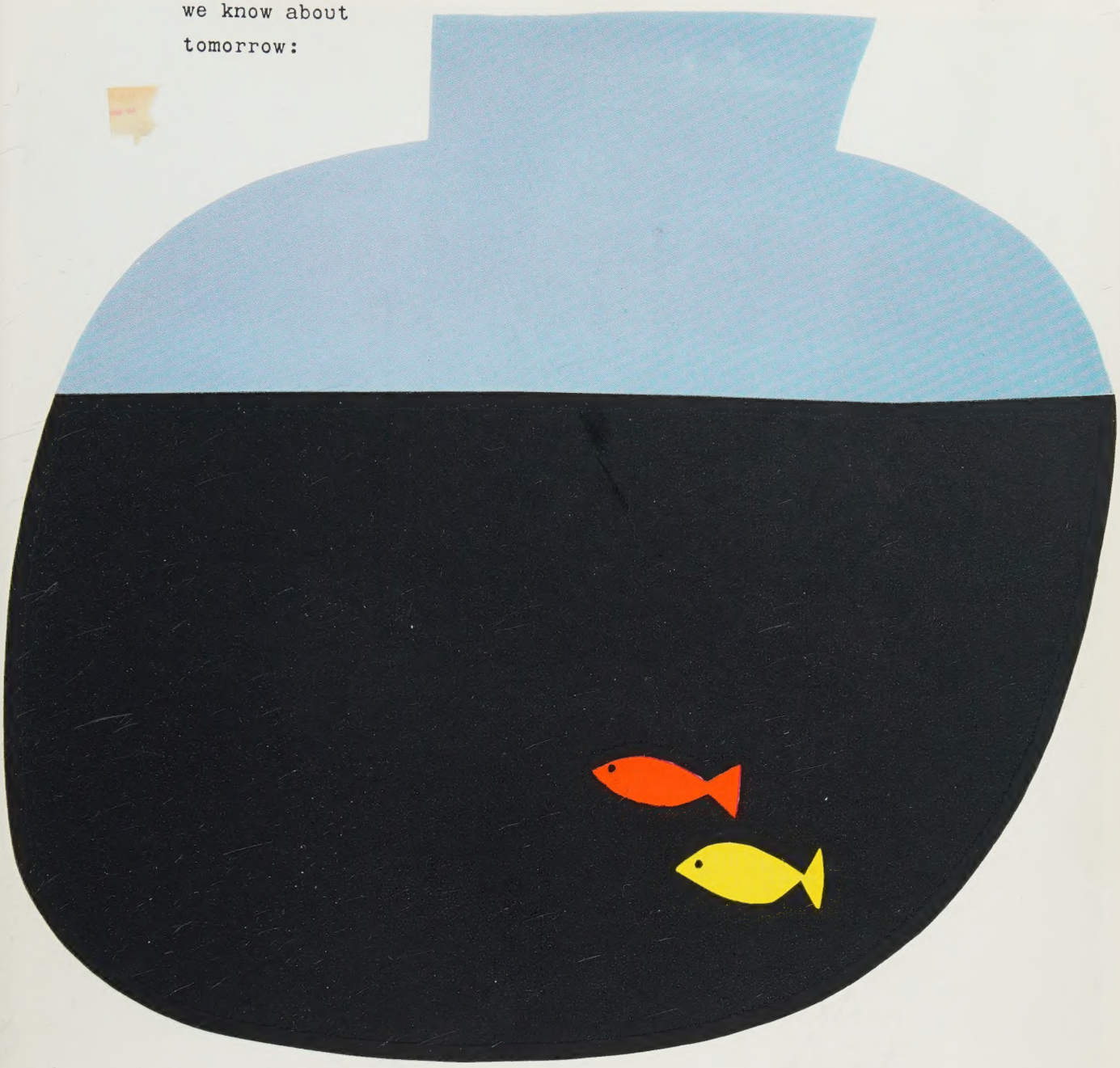

Man is like a Goldfish in a Bowl of Ink... His view of the "ultraviolet universe" is shut off by the blanket of air which surrounds him.

The earth's atmosphere is like the ink in a goldfish bowl. It absorbs so much of the ultraviolet light from outer space that little gets through to show us what lies out there.

But now, an electronic imaging tube, sensitive to this ultraviolet light has been developed by Westinghouse Research scientists. Westinghouse is working with the Smithsonian Institution and the National Aeronautics and Space Administration to mount these tubes in satellites so that they can "see" in outer space and radio their findings back to earth.

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THE ILLINOIS TECHNOGRAPH

Volume 76, Number 1 **October, 1961**

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Cover . . .

This month's cover is Jim Simon's representation of the optical maser. This instrument is a significant breakthrough in the world of communication. Read all about the maser on page 10 of this issue.

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Looking Ahead with Phillips Petroleum . . .

AN EXAMPLE OF GROWTH BASED ON RESEARCH

Phillips Petroleum Company began putting science to work in company laboratories very early in its history. Back when natural gas was still being flared as a "waste" product, Phillips scientists were discovering new, profitable uses for it and the liquids extracted from it. Acting upon this knowledge, Phillips management amassed huge reserves of natural gas when it was still generally considered to be of little use.

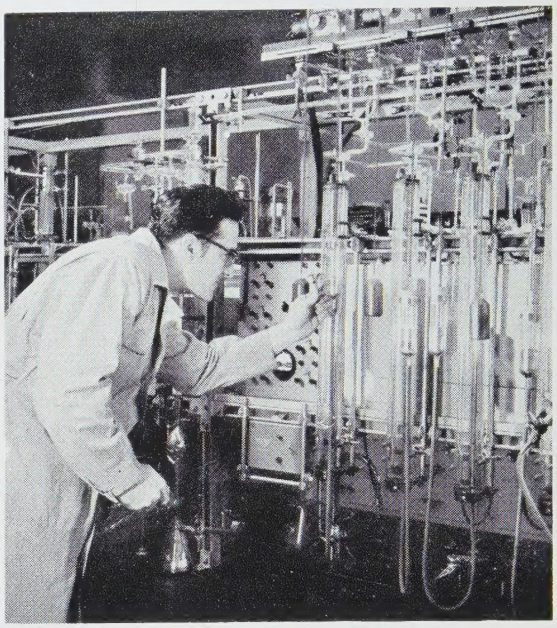
With this foundation of raw materials and technology, Phillips has attained a commanding leadership in natural gas, natural gas liquids, and petrochemicals. This base has been especially valuable in the chemicals field, where intense competition permits a nod of success only to companies with supplies of the proper raw materials and the know-how assembled from long experience and research.

From Phillips intensified emphasis on research and development through the years came many notable, profitable discoveries or developments. Among these are "cold" synthetic rubber; oil furnace carbon blacks; HF alkylation and other refining processes; high density polyolefins, trademarked Marlex; and all-season motor oils.

Three times the company has won the coveted "Chemical Engineering Achievement Award" for its research and development accomplishments, once by itself and twice in group awards.

Although research solves problems and develops know-how, an important measure of its results is patents. For many years Phillips has ranked second in number of patents issued and in total number of U. S. patents owned among all U. S. oil companies. The most recently available figures show Phillips ranks eighth in this respect among companies in all industries in America.

Intensive and consistent research effort has equipped Phillips with a qualified and dedicated research and development team. Although many of Phillips 3,000 scientists and engineers are located at the modern Phillips Research Center near the company headquarters in Oklahoma, others may be found in vital centers elsewhere. These people are thinking and working not only on exciting and challenging projects for the years



ahead, but also to make existing operations more profitable and to quickly commercialize newly developed processes and products. In short, their emphasis is upon converting ideas into earnings.

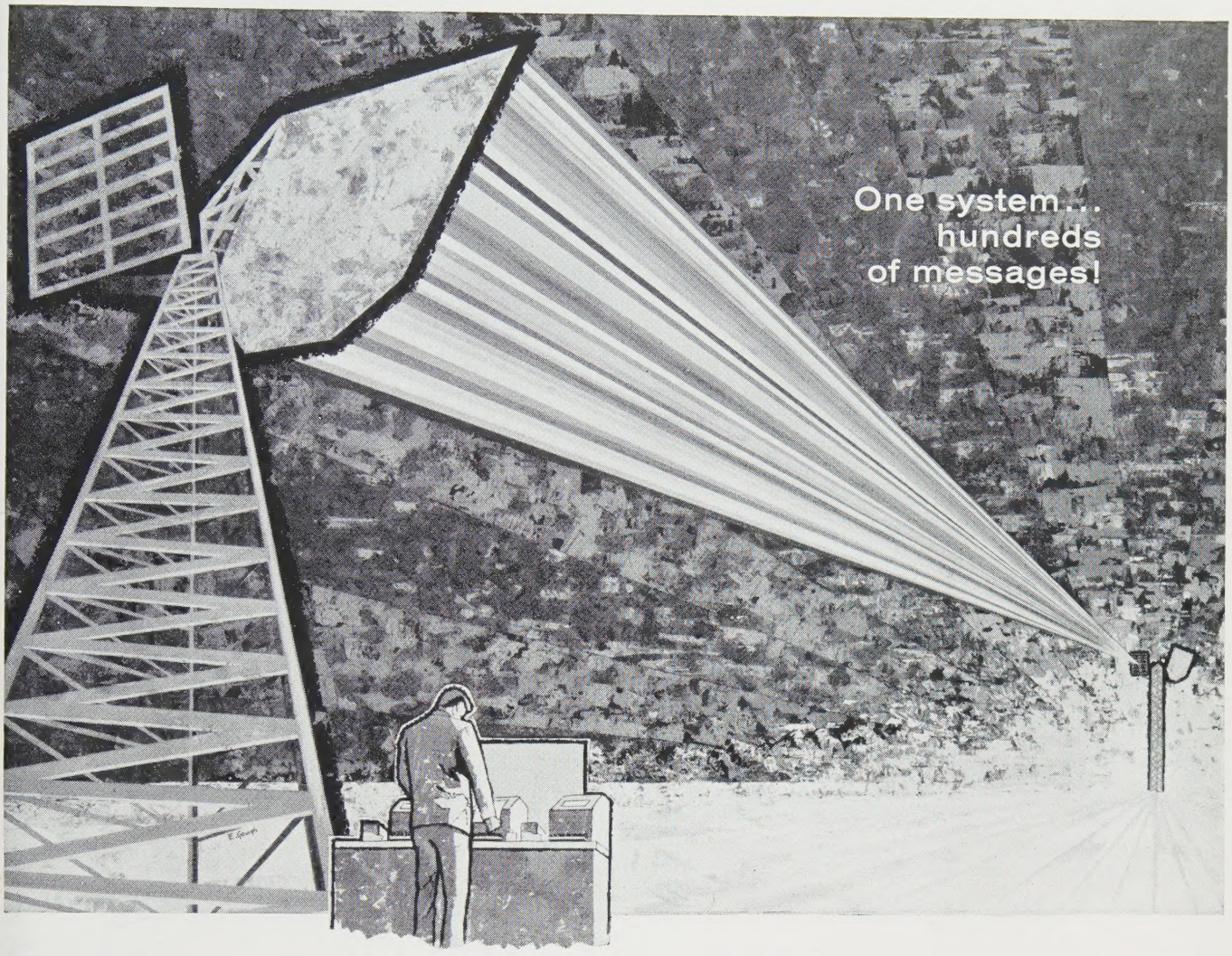
One of the most recent major petrochemical achievements of Phillips research is cis-polybutadiene rubber, trademarked Cis-4. Extensive tests have shown this rubber to be superior to natural rubber in tire tread wear and in other important qualities, including blowout resistance and traction on snow and ice. The company's 25,000 ton per year Cis-4 plant has commenced production. The process has been licensed to others both in the U. S. and abroad.

There is always an undisclosed backlog of discoveries and inventions to which Phillips scientists are giving "finishing touches" prior to commercialization. Some now or soon emerging are a new jet fuel additive solving a vexing aircraft problem, a new polypropylene process, and a better seismic prospecting method.

Research is one reason for "Looking Ahead With Phillips."

PHILLIPS PETROLEUM COMPANY, Bartlesville, Oklahoma

PHILLIPS 66



Automation through communications

works wonders in speeding the flow of business information

A revolution in communications is taking place—a revolution that is destined to open vast opportunities for increasing business efficiency while lowering costs. Thanks to advances in the high-speed, high-volume transmission of information electronically, it is now possible to close the "communications gap" that hampers so many industries.

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Lenkurt Electric is working in close alliance with telephone companies to bring the modern-day benefits of *automation through communications* to business and industry.

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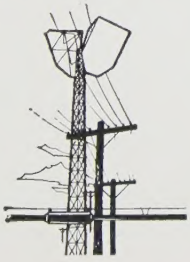

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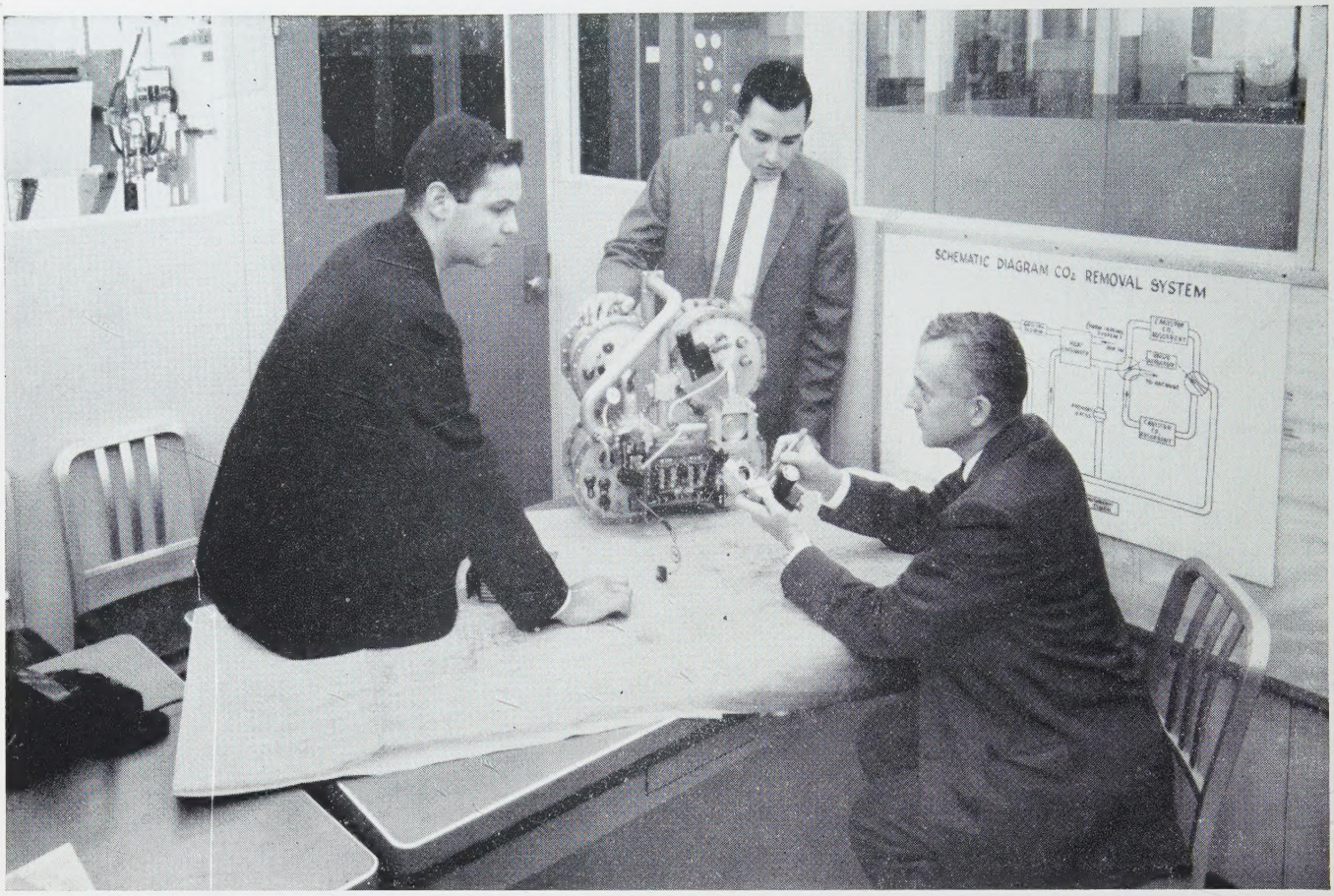

1961 Graduates, Ron Bullota (Villanova, BS-ME) and Robert Schwartz (R. P. I. MS-ME) review contaminant (CO_2) removal system for space vehicle with Fred Young (Penn State, BS-ME, '43), Project Engineer—Advanced Development

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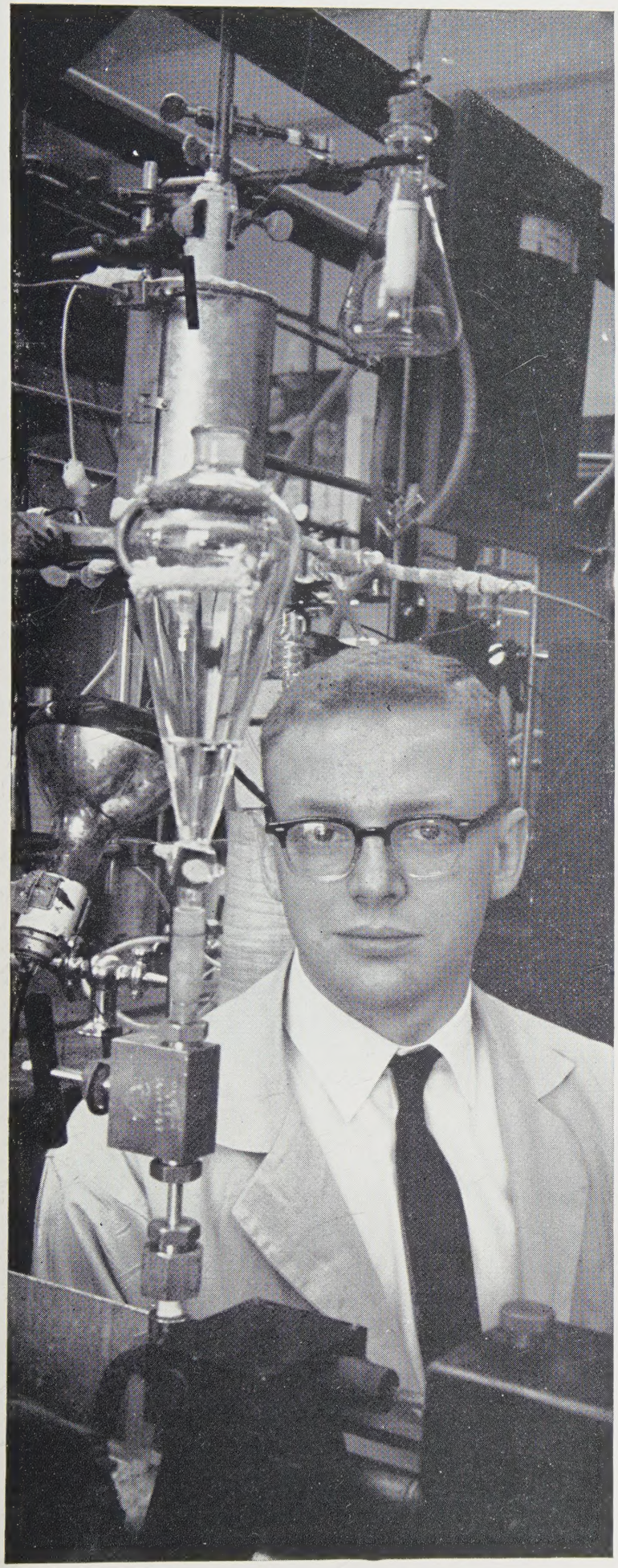

Some straight talk about a career at American Oil

by Roger Fisher

"This Company recognizes the value of varied experience, and encourages you to broaden your knowledge."

Roger Fisher, B.Ch.E. from Cornell and Ph.D. candidate from Princeton is one of many young scientists and engineers at Amer.can Oil shaping the future for himself, his Company and the industry. At 26, he has earned a Fulbright Scholarship and will take a year's leave of absence to continue his graduate research on solids mixing at the University of Osaka, Japan.

"American Oil is looking for broad-gauge research people," Roger adds. "In the long run, the Company benefits as well as the professional who continues to grow in his own or in several fields of research."

Roger's present assignment at American Oil involves applied research—to plan, design, build and operate bench scale lab equipment, to study the kinetics of catalytic cracking. His is one of many diversified projects at American Oil Company. Chemists, chemical engineers, physicists, mathematicians and metallurgists can find interesting and important work in their own fields.

The ability of American Oil to attract bright young scientists and engineers like Roger Fisher might have special meaning to you. For complete information concerning career opportunities in the Research and Development Department of American Oil, write D. G. Schroeter, American Oil Company, P. O. Box 431, Whiting, Indiana.

IN ADDITION TO FAR-REACHING PROGRAMS INVOLVING FUELS, LUBRICANTS AND PETROCHEMICALS, AMERICAN OIL AND ITS ASSOCIATE COMPANY, AMOCO CHEMICALS, ARE ENGAGED IN SUCH DIVERSIFIED RESEARCH AND DEVELOPMENT PROJECTS AS: New and unusual polymers and plastics • Organic ions under electron impact • Radiation-induced reactions • Physiochemical nature of catalysts • Fuel cells • Novel separations by gas chromatography • Application of computers to complex technical problems • Synthesis and potential applications for aromatic acids • Combustion phenomena • Solid propellants for use with missiles • Design and economics: New uses for present products, new products, new processes • Corrosion mechanisms • Development of new types of surface coatings

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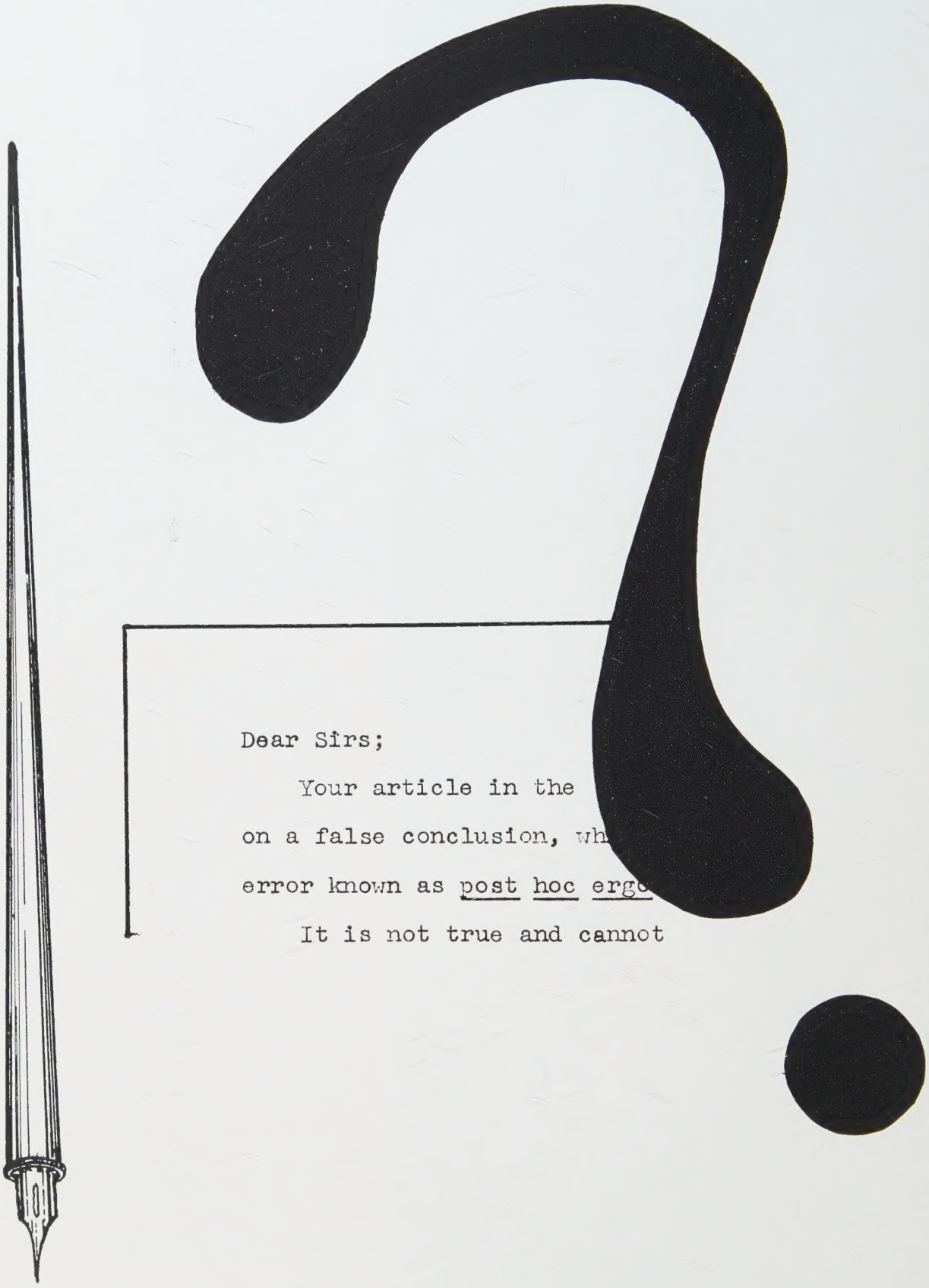

Dear Sirs;

Your article in the

on a false conclusion, wh

error known as post hoc erg

It is not true and cannot

A Necessary Anger . . .

In this world of ordinary people, a man of action is a valuable and extraordinary thing. Too many people today have a rather tame outlook. They seem to think that if dangerous situations are left to heal themselves, nature will somehow run its course and good conquer all. Unfortunately the wound often festers and infects the whole world. History will bear witness to this statement. The 1940's weren't pleasant by any stretch of the imagination, and the presently warming cold war is another example of an unattended wound in the world's side. Why worry about communism? The pacifists would rather be red than dead. So what if everyone hates yankees, but loves yankee dollars? There is plenty of money to be thrown after what is already down the drain. This fortress America can stand off the African and Asian hordes any day of the week. The man of action cannot sit still in this situation. He cannot listen to demagogic hogwash without clenching a fist. The hero of the **Ugly American** was just such a man. He also just happened to be an engineer. Though the novel was a fictional account of our Southeast Asian bungling, it does prove that somebody out there likes engineers. Somebody thinks that these thoughtful, practical people are capable of doing some good. We as student engineers are rather limited as to any action we can take on an issue. There is some outlet for anger that any of the ugly young American engineering students generate. The Letters to the Editor Column in TECHNOGRAPH is available for the venting of spleen. But TECH never had a Letters to the Editor column! It does now and you are invited to write about anything your little heart despises. If you want to see some change in the curriculum, or some prof removed, let this magazine know about it. We will print anything but pornography and may answer any cryptic comments we disagree with. Tell us why you want the bomb banned and we guarantee to print it and laugh. Here is a call to action. We may even find a partner for you if you are just looking for a fight. Address all letters to:

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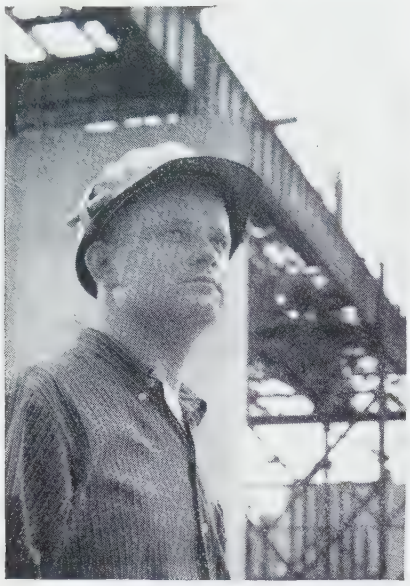
—S. H. Altman



• One in a series of messages on how to plan your career

The Bethlehem loop course

What it is and how it works

The Loop Course is our program conducted annually for selecting and training qualified college graduates for careers with Bethlehem Steel. It was established 40 years ago. From the very beginning, it included an observational circuit (or "loop") of a steel plant, ergo the name. Many men holding key positions with Bethlehem today entered the company through the Loop Course.

Promotion from Within—The Loop Course is specifically designed to provide management personnel. Since it is our policy to promote from within, it is vital that competent men, well-grounded in our practices and policies, be available to fill management openings as they occur. And, due to Bethlehem's steady growth, there has been no lack of opportunities to advance.

The Basic Course—Every looper attends the initial five-week course held at our home office in Bethlehem, Pa., beginning early in July. He attends orientation lectures, listens to discussions by management men on all phases of company operations, and makes daily trips through the local steel plant. At the end of this period he has a sound basic knowledge of the Bethlehem organization.

Their First Assignments—At the end of the basic course, loopers receive their first assignments. Ordinarily a large majority report to our steelmaking plants, where they attend orientation programs much like the initial one at Bethlehem, but more specialized. During this period plant management closely observes each looper's aptitudes and interests, with the objective of assigning him to the department or job for which he appears to be best fitted, and corresponding as closely as possible to his educational background and work preferences.

Specialized Training—Loopers selected for sales, mining, shipbuilding, research, and the company's administrative departments, proceed from the basic course to specialized training programs varying according to the type of work.

Preparing for Advancement—As the looper gains in ability, experience, and knowledge, and as openings occur, he is moved into positions of increasingly greater responsibility. The company expects and encourages the looper to produce, to make steady progress. Regular reports as to his work and progress are made to department heads —and annual reports to divisional vice-presidents—throughout his career.

Emphasis on Technical Degrees—Because of the nature of Bethlehem's activities, the greatest demand is for men with technical degrees, especially those in mechanical, metallurgical, industrial, electrical, chemical, civil, and mining engineering.

Read Our Booklet—The eligibility requirements for the Loop Course, as well as a description of the way it operates, are more fully covered in our booklet, "Careers with Bethlehem Steel and the Loop Course." It will answer many questions undergraduates may have. Copies are available in most college placement offices, or may be obtained by writing to Manager of Personnel, Bethlehem Steel Company, Bethlehem, Pa.

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

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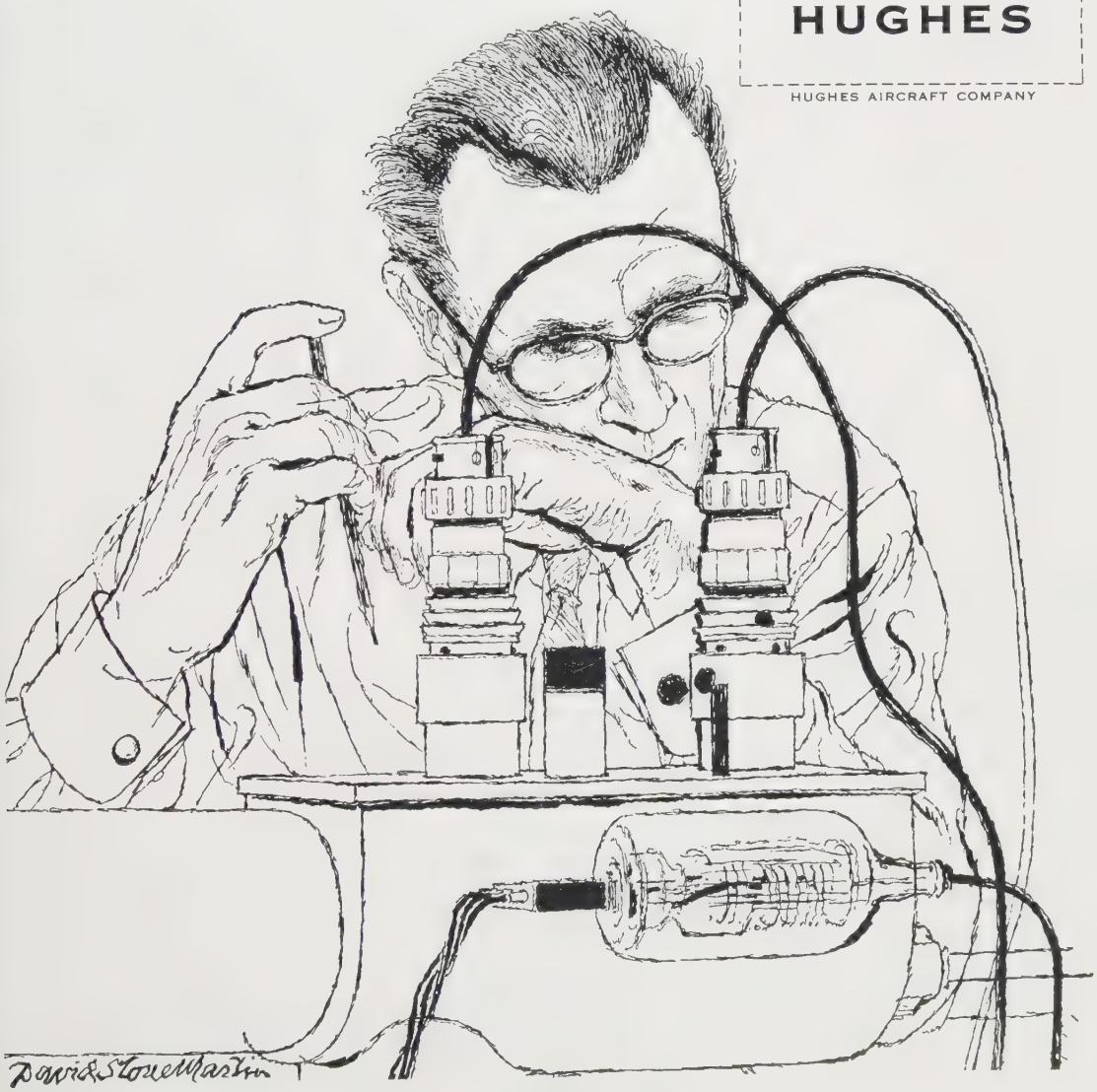


Infrared and Optical Masers

Edited by Harry Brattin, M.E. '62

The material for this article was furnished by the Illinois Bell Telephone Company and the Bell Telephone Laboratories.

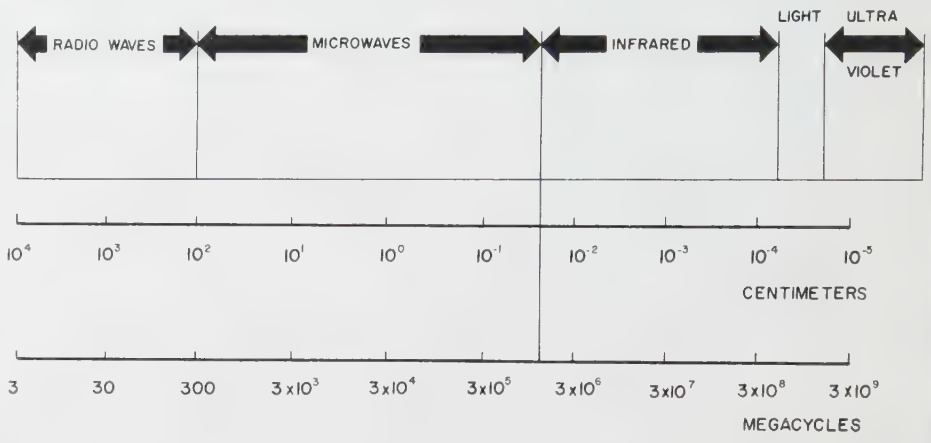
Ever since the earliest days of radio communication, there has been a steady drive toward the production and use of electro-magnetic waves of higher frequencies and, correspondingly, shorter wavelengths. For this purpose, electron tubes have been refined through the years, and in the last decade they have been joined by transistors and other semiconductor devices. Today, with both tubes and semiconductor devices, we can produce wavelengths as short as about a millimeter, corresponding to a frequency of 300,000 megacycles. However, continued progress in the construction of high-frequency devices has always been limited by some critical dimension which becomes inconveniently small as the wavelengths are reduced.

Recently, promise has come of a break-through in this dimension-wavelength-frequency barrier. It now seems possible to apply electronic techniques to much higher frequencies using the "maser" principle. Since the invention of the first molecular-beam maser by C. H. Townes, of Columbia University, these devices have been used as frequency standards and as microwave amplifiers having very low noise. The most recent application, invented jointly by C. H. Townes and A. L. Schawlow will produce "coherent" high frequencies by stimulating radiation from atomic systems in the frequency band emcompassing the optical in infrared regions.

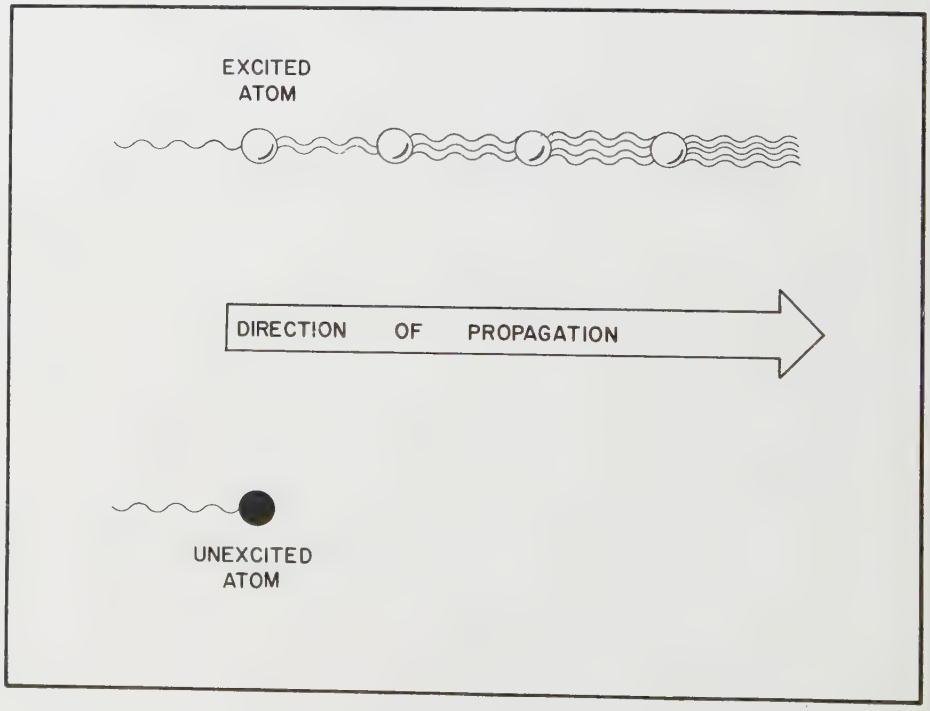
What are the advantages to using high frequencies? One important application is in carrier transmission. To transmit information, no matter what kind of modulation is used, we need a band of frequencies. To transmit more information, we need a wider band of frequencies. For example, a television program needs a channel of several megacycles wide, while a telephone conversation requires one of only a few kilocycles.

As the volume of information to be transmitted increases, more and wider channels are needed. With large bandwidths, we can transmit many telephone conversations and several television programs with the same equipment. Now, as the carrier frequency is raised, a given percentage bandwidth, which might be dictated by practical considerations, is a proportionately larger absolute bandwidth. Thus, more information can be transmitted with high carrier frequencies and their accompanying large bandwidths.

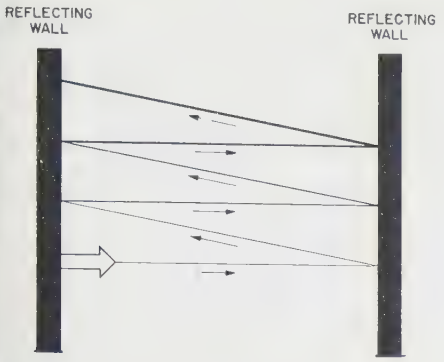
A second major advantage of high frequencies has to do with directivity. Higher frequencies imply shorter wavelengths, and these waves can be beamed sharply by an antenna of given size. Now that we wish to communicate with small satellites and space vehicles at



Sketch I: Some of the major divisions of the electromagnetic frequency spectrum. Boundary near one million megacycle marks change in method of frequency generation. Below this point are easily generated single frequencies. Above it are broadband waves to sort out for propagation purposes.



Sketch II: Growth of a light wave by stimulated emission. Wave striking excited at same frequency forces it to "join" the original emission. Unexcited atom absorbs wave and ends emission.



Sketch III: One arrangement of optical maser in which wave "grows" as it bounces back and forth between reflecting walls.

great distances, there are strong reasons for seeking the highest possible directivity in a very small package.

Electron-Tube Generators

In their quest for higher frequencies and shorter wavelengths, engineers have built electron tube oscillators that produce frequencies as high as 100,000 megacycles. With harmonic generators, we can derive multiples of these frequencies as much as ten times higher. This corresponds to a wavelength of a few tenths of a millimeter—about one hundredth of an inch. The spectrum chart (sketch 1) shows this point. Below 1,000,000 megacycles in frequency (that is at longer wevelengths) lies the radio waves and above this point are the infrared and optical wavelengths.

All of these are electromagnetic waves; they differ primarily in wavelength or frequency. But because at this point there is an abrupt change in the way the waves are generated, there is one important difference in their nature. Radio waves generated by electron tubes have a single, definite frequency like a pure tone in sound. Light waves, on the other hand, always cover a fairly broad band of frequencies and so are more akin to noise than to a tone.

This comes about because light waves are generated by many individual atoms or molecules. Each of these emits radiation for a short interval, and is succeeded by others with a slightly different frequency. Since these individual oscillators are entirely independent, there is no connection between their phases. Thus the emitted wave has a phase that fluctuates randomly from moment to moment, and from point to point in the source. It is almost completely lacking in coherence. An electronic oscillator, with its phase progressing smoothly in time, is coherent.

Coherence in an electronic generator is an important advantage because it permits us to "beat" together waves of different frequencies, as in superheterodyne detection. Beating an incoming signal with a local oscillator in the "receiver-mixer" stage of a radio receiver permits us to convert the signal to a lower frequency band where, in some cases, it can be more easily tuned and amplified. Another advantage of a coherent source is that we can supply separate radiation elements with properly phased radiation for a directive antenna. Therefore, we can radiate waves coherent in space as well as in time.

Thus it would be most desirable to have powerful sources (amplifiers and oscillators) of coherent radiation in the infrared and optical regions of the frequency spectrum. As mentioned before, one approach to this is to continue scaling down electronic tubes to smaller dimensions. This approach has been very successful in the past and will continue, but becomes more and more difficult for signals at shorter wavelengths. Moreover, if man-made resonators of any kind are used, they become increasingly tiny and hard to make accurately because their dimensions must be comparable with a wavelength.

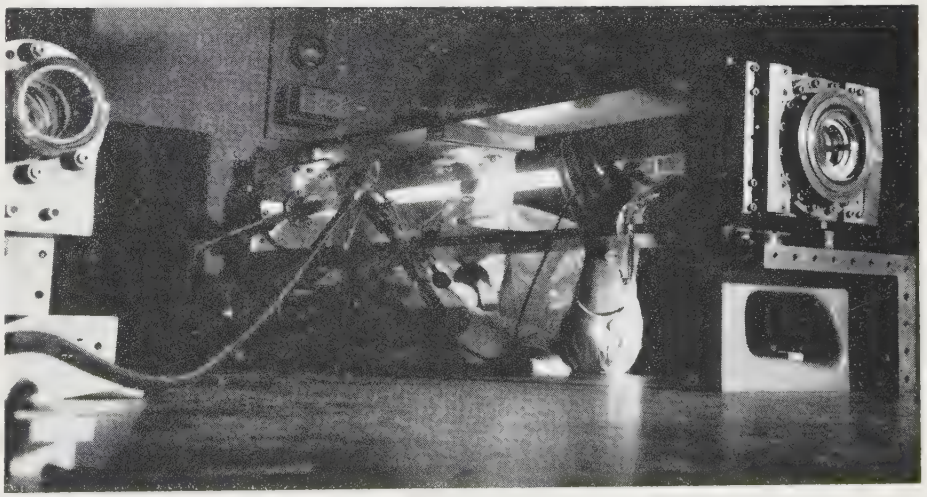
On the other hand, nature has endowed us with a copious supply of atomic, ionic and molecular resonators at almost all frequencies in this region. We need only find some way to excite them and then synchronize them so that they are made to radiate coherently. This much has been known for a long time, and indeed such light sources as gas-discharge lamps—the ordinary fluorescent light, for example—make use of radiation from excited atoms or molecules. But only since the invention of the maser has there been any indication of how the individual "radiators" might be synchronized.

The term maser is an acronym derived from "Microwave Amplification by Stimulated Emission of Radiation." Since there are now stimulated-emission devices in almost all frequency ranges, it seems best to change the "m" to stand for "molecular." Then we can retain the name for all the devices, whether microwave or not.

All atomic and molecular systems possess discrete energy levels, which are different for each kind of system. That is, they can store energy of certain fixed amounts only. An atom in its "ground" state can absorb energy from an electromagnetic wave of the right frequency, and make a transition to an excited state. Once in the excited state, the atom could lose the energy by spontaneously emitting a wave "quantum" of the same frequency as the one which originally excited it. Or, while the atom is excited, if another similar quantum comes along, it can force the atom to emit its radiation and revert to the ground state.

A maser makes use of this stimulated emission. We can construct one so that in the material an excess of atoms is maintained in the upper energy state. Then an incoming wave of the proper frequency gains energy by stimulating emission from these atoms.

Sketch 3 illustrates the growth of a light wave by stimulated emission. Let us suppose that the wave travels from left to right through an active medium. Active mediums contain mostly atoms in the upper state indicated by the top "ball" in the sketch. When a light wave of the proper frequency strikes one of these excited atoms, the atom is forced to emit radiation of the same frequency, giving up its excitation energy in the process. Moreover, the stimulated emission is in phase with the original, and so aguments it. Thus, as the wave progresses from left to right, it grows, or is amplified, by this process of stimulated emission. On the other hand, if the wave strikes an atom in the lower energy level (indicated by the bottom ball in the sketch) it may excite the atom, losing energy in the process. Thus



The heart of the optical maser is a 40-inch tube filled with helium and neon. Interactions between gas atomsproduces a coherent beam of infrared light that may one day be used to carry vast numbers of telephone calls and television programs.

for amplification, the number of atoms in the upper, or excited state must outnumber those in the lower state.

We can convert this maser amplifier into an oscillator by feeding back some of the amplified output. This is done simply by terminating the active medium with reflecting end walls (see sketch 2). A wave which travels along the axis of the system can now bounce back and forth, returning to its starting point. In fact, it can form a standing wave system between the plates. Such sustained oscillations are obtained if the amplification of a wave traveling from one end plate to the other exceeds the loss on reflection at the ends. Of course, the signal must be extracted somehow. Making one of the end walls partly transparent permits some light to be extracted through it.

If the maser is producing light waves in or near the visible region, there will be many thousands of wave lengths between the end plates. These reflecting plates should be flat within a small fraction of a wavelength of light, but techniques for polishing plates to such flatness were developed long ago for other optical instruments. Thus, the whole system does not have to be comparable in size with a wavelength, but can be much larger.

For microwaves, the most commonly used "tuning" element is the cavity resonator. This is a hollow box inside which the radio waves bounce. When the length of an incoming wave has the right relation to some dimension of the box, there is a resonance. Ordinarily, microwave cavity resonators are comparable in dimension to one wavelength, usually about a centimeter.

If we were to use a "large" cavity resonator for light waves, it would resonate in very many modes. However, the optical maser described here would have only the ends reflecting and therefore would only be a good resonator for waves traveling along its axis. The other modes of the cavity resonator correspond to waves traveling in other directions. Most of these will miss the end plates entirely and will spend little time in the region of the active medium. Those only slightly off the axis will hit the end plates a few times and then pass the edge of the reflector and be lost. If the end plates are small enough in comparison with their separation, only waves traveling accurately along the axis will be amplified or generated. Then the light emerging from the partially transparent end plate will also be traveling along the axis of the system.

Thus the output of the optical maser is a wave which is inherently very directional. We expect that the radiation would initially have an accurately plane

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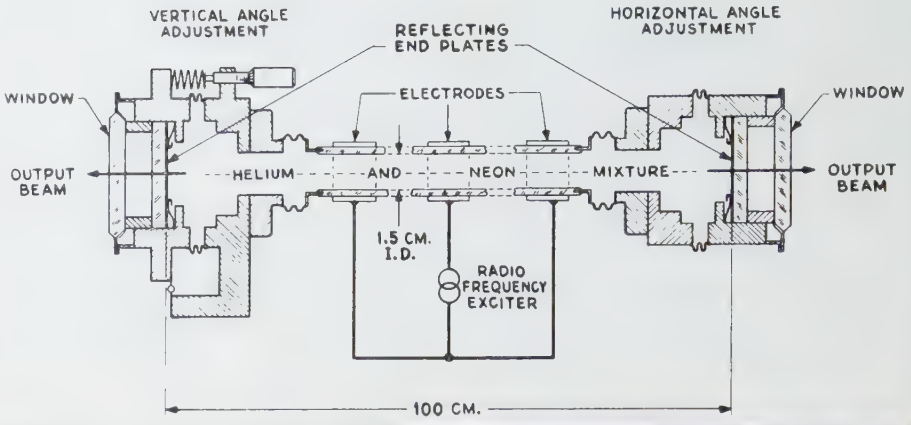
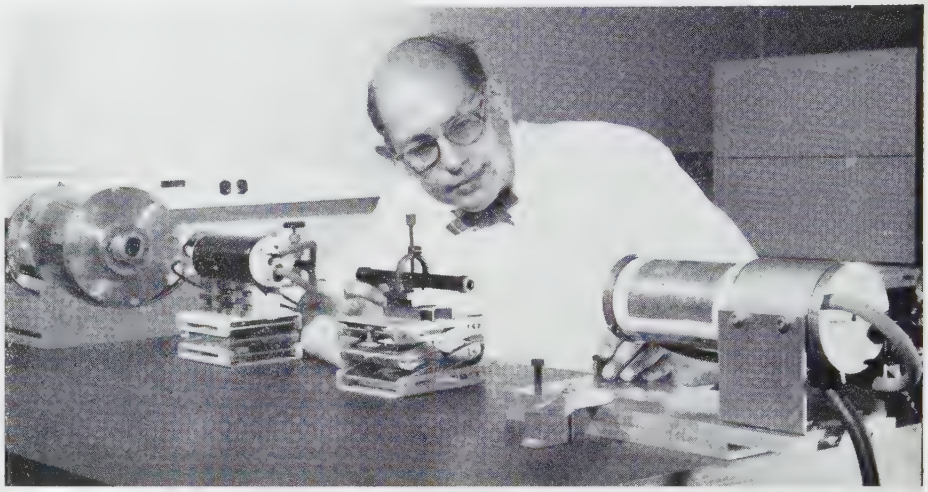
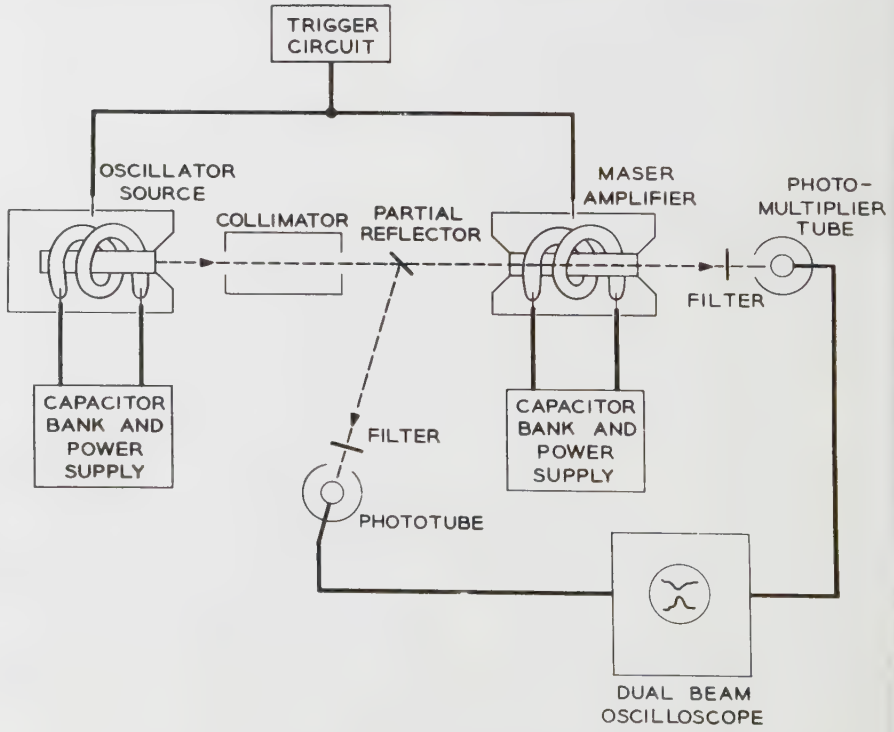
GASEOUS OPTICAL MASER





The collimator directs the beam from a ruby maser oscillator (right) through the ruby maser amplifier (center to the photomultiplier tube (in the far left.



Light amplification in a ruby maser can be observed directly by using this experimental setup. The signal source is a conventional ruby maser. The collimator directs the light so that it hits the side of the amplifying ruby or is masked by the amplifier housing.

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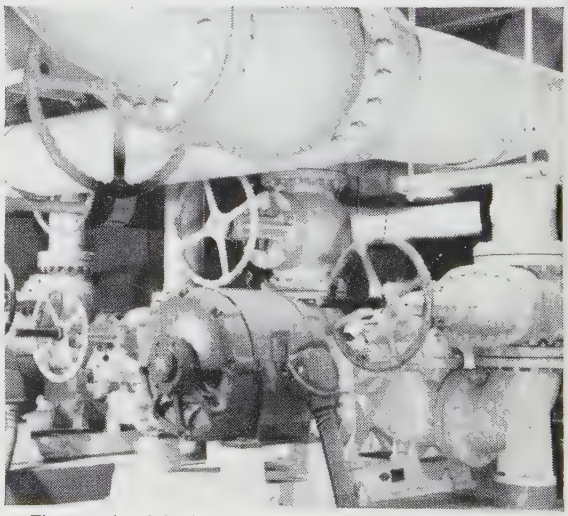

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TECHNICAL GUIDANCE BY THE ENGINEERING ALUMNI COMMITTEE

By Dean H. L. Wakeland

In recent years numerous films, publications, and television programs have been produced in an ever widening attempt to inform our youth about the fields of science and engineering. By in large, most of these presentations have not attempted to "sell" engineering and science careers to our youth, but rather to provide adequate information so that they might intelligently make their own decision whether to enter this field or not.

Though many of these guidance aids are presently available, freshmen entering college indicate that personal contacts and individual acquaintances are still the greatest single factor influencing their decision to enter a specific educational field. In many cases, the contacts are limited to family friends or high school faculty members who may not have a clear conception of the field of engineering or science themselves.

Realizing that personal contact, guidance, and presentation of engineering opportunities was still the most effective way of reaching prospective students, Dean Everitt organized the University of Illinois Engineering Alumni Committee in 1952. He envisioned a group of "practicing engineers" throughout Illinois that would take time from their busy and productive lives to guide and counsel young people interested in entering the field of engineering. The group has continued to grow each year since 1952 and now has 144 members.

The Engineering Alumni Committee, selected from University of Illinois graduates, make themselves available for individual or group conferences in their local community. More often than not, these services are coordinated through high school in or near the locality in which they live. In some cases, the committee members are willing to travel long distances to return to the high school from which they graduated. In all cases, they make a determined effort to answer the questions which trouble secondary school administrators, faculty, and parents and are willing to counsel students individually or in groups. Committee members are commonly asked to speak at high school "Career" or "College" days and youth guidance programs sponsored by local service clubs.

The purpose of the committee is not to recruit students for the University of Illinois, but to describe and explain the many opportunities in the field of engineering. They also emphasize proper educational preparation for college entrance and success. Through the committee, it is possible to carry on the close liaison desired with local high schools and the high schools which have committee representatives are indicated on the accompanying map of Illinois. Members representing schools out of the state are not shown. The high schools represented and their committee representative are given in the accompanying directory.

Each year an Annual Engineering Alumni Committee Meeting is held, usually during a football weekend in the fall. During this meeting, members are briefed on new developments and changes in the College of Engineering and the University. Every member is presented with a handbook which helps to keep them up-to-date and provides much information which is often sought by local high schools. Films and publications produced by the college are also available, free of charge, through committee members.

The College of Engineering is interested in expanding the membership of the Alumni Committee in order to provide the personal contact with as many high schools as possible. Though we continue to improve publications and films, personal contact and individualized presentations are still most effective in providing educational guidance for young people. One of the greatest services the College of Engineering can provide to the people of Illinois is an informed group of practicing engineers willing and able to take time from their busy lives to provide guidance for young people.

Engineering Alumni Committee Directory Listed by High School

ILLINOIS MEMBERS

Abingdon, Senior H.S.—Daggett, T. E., 1811 McMasters St., Galesburg, EE50.

Alton, Senior H.S.—Webb, John L., P.O. Box 267, Godfrey, ME40; Shanahan, George H., 930 Henry St., Alton, CE27.

Arlington Heights, Senior H.S.—King, Elwyn H., 917 S. Owens St., Mt. Prospect, CE42.

Aurora. West Senior H.S.—Dietiker, Francis D., 19 S. Western Ave., Aurora, CE42; Lyons, James E., 233 S. Western Ave., Aurora, EE45.

Aurora, East Senior H.S.—Hoefle, Ronald A., 145 Edgelawn Drive. Aurora, CE51.

Avon, Senior H.S.—Daggett, T. E., 1811 McMasters St., Galesburg, EE50.

Barrington, Consolidated H.S.—Geuss, Arthur P., Haney Lake & Kimberly Road, RFD No. 1, Barrington, CE34.

Beardstown, Community H.S.—Donaldson, Robert W., Central Ill. Pub. Serv. Co., Beardstown, EE50.

Belvidere, Senior H.S.—Lamb, Miles, 457 Fullerton Parkway, Chicago 14, CE40.

Benton, Consolidated H.S.—Padavic. Frank J., Old Ben Coal Corporation, 500 W. Main St., Benton. Min. 50.

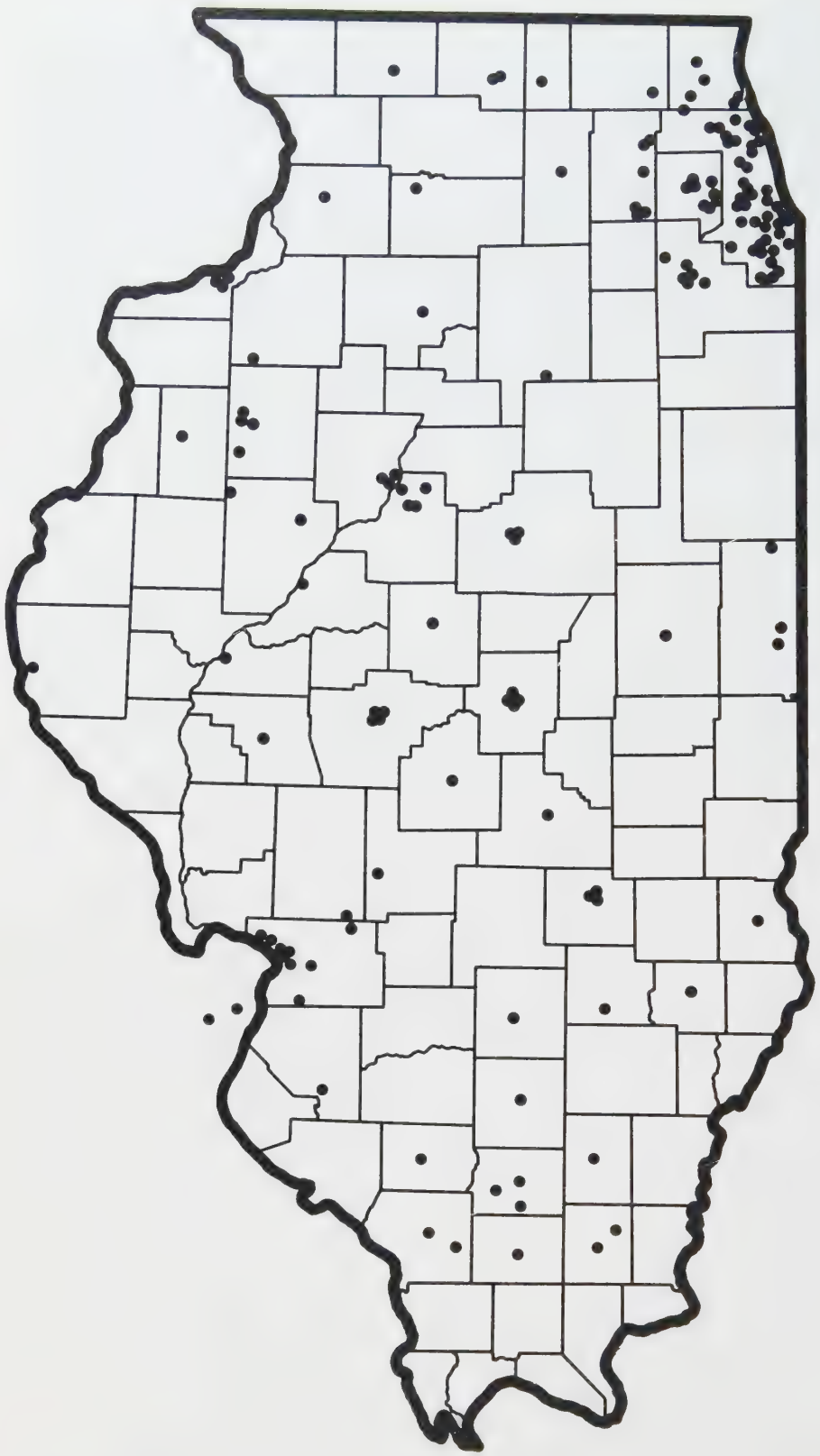
Bloomington, Senior H.S.—Dennis, Robert J., General Telephone Co., 1312 E. Empire St., Bloomington, EE49.

Bloomington, Trinity H.S.—Dennis, Robert J., General Telephone Co., 1312 E. Empire St., Bloomington, EE49.

Blue Island, Community H.S.—McAtee, Fay E., 10320 S. Bell Ave., Chicago 43, CE30.

Calumet City, Thornton Fractional H.S.—Pontious, Robert L., 3425 S. Schultz Drive, Lansing, ME49.

Canton, Senior H.S.—Birkey, W. R., Central Ill. Pub. Serv. Co., 102 E. Elm St., Canton, EE50.



Location of Illinois High Schools having Engineering Alumni Representatives. University of Illinois, 1961.

Carbondale, Community H.S.—Stallman, William E., 1012 S. Oakland St., Carbondale, CE50.

Attucks Community H.S.—Stallman, William E., 1012 S. Oakland St., Carbondale, CE50.

Southern Ill. Univ. H.S.—Stallman, William E., 1012 S. Oakland St., Carbondale, CE50.

Champaign, Senior H.S.—Atkins, Clinton P., 1105 S. Pine St., Champaign, CE42.

Chicago, Fenger H.S.—Howard, Kenneth, 9323 S. Longwood St., Chicago 28, EE29; Wofford, Thomas D., Ill. Central Railroad, 135 E. 11th Place, Chicago 5, CE46.

Morgan Park H.S.—Rich, Ktith, 11521 S. Oakley Ave., Chicago (Riverdale), ME 32.

Lane Technical H.S.—Reid, Donald J., 214 Davison St., Joliet, Associate Member.

Chicago, Hirsch H.S.—Mathews, W.B., 2052 E. 69th St., Chicago 49, ME22.

Mendel Catholic H.S.—Mahn, G. W. Jr., Ill. Central Railroad, 135 E. 11th Place, Chicago 5, CE48.

Bowen H.S.—Guild, W.G., 8146 Luella Ave., Chicago 17, CE26.

Univ. of Chicago H.S.—Epstein, Sidney, 2011 W. Pershing Road, Chicago 9, CE43.

Lake View H.S.—Goedjen, Merle H., 1924 W. Morse Ave., Chicago 26. CE32.

Morgan Park H.S.—Stevens, R.P., 1625 W. 104th St., Chicago 43, Cer34.

Steinmetz H.S.—Larson, Arthur P., 1405 S. Fairview Ave., Park Ridge, ME32.

General Rep.—Rich, F.M., Vice Pres., Steel Mfg., Inland Steel Co., 30 W. Monroe St., Chicago 3, ME25.

Chicago Heights,—Lindstrom, Fred H. Vacudyne Corp., 14419 S. Torrence Ave., Chicago 33, ME45.

Christopher, Community H.S.—Padavic, Frank J., Old Ben Coal Corp., 500 W. Main St., Benton, Min. 50.

Cicero, J. Sterling Morton Twp. H.S.—Novy, Otto R., Chicago Pottery Co., 1920 N. Clybourn St., Chicago 14, Cer.41.

Collinsville, Community H.S.—Crawford, George L. No. 2 Orchard Lane, Collinsville, CE50.

Crystal Lake, Community H.S.—Campbell, Ralph E., 366 Hilkert Court, Crystal Lake, EE25.

Danville, Senior H.S.—Brooks, Wesley W., Ballast Department, General Electric Co., 1430 E. Fairchild St., Danville EE33.

Decatur, Decatur H.S.—Shultz, Emerson A., 215 S. Woodale St., Decatur, EE31; Sentman, Lee H. J., 61 E. Moreland St., Decatur, C731; Beinhauer, Frank H. 564 Bradley Court, Decatur, CE28.

MacArthur H.S.—Reeves, Richard E. Director of Engineering, Decatur Pump Co., 2750 Nelson Park Road, Decatur, Ag.E.47.

Deerfield, Senior H.S.—Laegeler. C.J., the Frank G. Hough Co., Libertyville, ME43.

DeKalb, Senior H.S.—Pearson, H. T., 102 Wendell Place, DeKalb, EE37.

Des Plaines, Maine Twp. H.S.—Cartland, Silas III, 911 Bussey Highway, Park Ridge, ME16-17-19-22; Catton, Miles, 926 St. James Place. Park Ridge, CE27; Hardacre, D. E., 1000 S. Harrison St., Park Ridge, ME41.

Dixon. Senior H.S.—Hofmann, Robert, 106 River St., Dixon, CE43.

Downers Grove H.S.—Saar, Robert P., 2222 S. Halsted St., Chicago 8, ME48; Dinsdale, David A., 4142 Washington St., Downers Grove, ME26.

East Moline, Township H.S.—Buss, B. A., Manager of Engineering, American Machine & Metals, Inc., East Moline, EE33.

East Peoria, Senior H.S.—Van Pelt, Richard H., 915 Birchwood Drive, Washington, Met.43.

Effingham. Senior H.S.—Burggraf, Carl I., 200 S. Second St., Effingham, CE14; Dinkheller, J. H., 305 Austin Ave., Effingham, CE49; Hedgcock, R.E., 204 Clark Ave., Effingham, CE22.

Eldorado, Township H.S.—Montgomery, Gill, Vice Pres. & General Mgr. Minerva Oil Co., Eldorado, Associate Member.

Engin, Senior H.S.—Meid, W. J., Engineered Ceramics Manufacturing Co., 1435 W. Fulton Ct., Chicago 12, Cer.E.45.; Knecht, Walter G., 525 E. Chicago St., Elgin, EE25.

Elmwood Park, Senior H.S.—Morris, Lloyd P., 2947 N. 78th St., Elmwood Park, EE28.

Elmhurst, Immaculate Conc. H.S.—Plankenhorn, W.J., Chicago Vitreous Corporation, 1425 S. 55th St.. Chicago 50, Cer.31.

Edwardsville, Senior H.S.—Blackmore, Joseph J., 4030 Chouteau Ave., St. Louis, Mo.

Evanston, Senior H.S.—Krug, Louis G.—734 Glen Court, Glenview, LAS17.

Flora, Township H.S.—Wineland, Gene K., 619 W. Somerset Lane, Peoria, Min.59.

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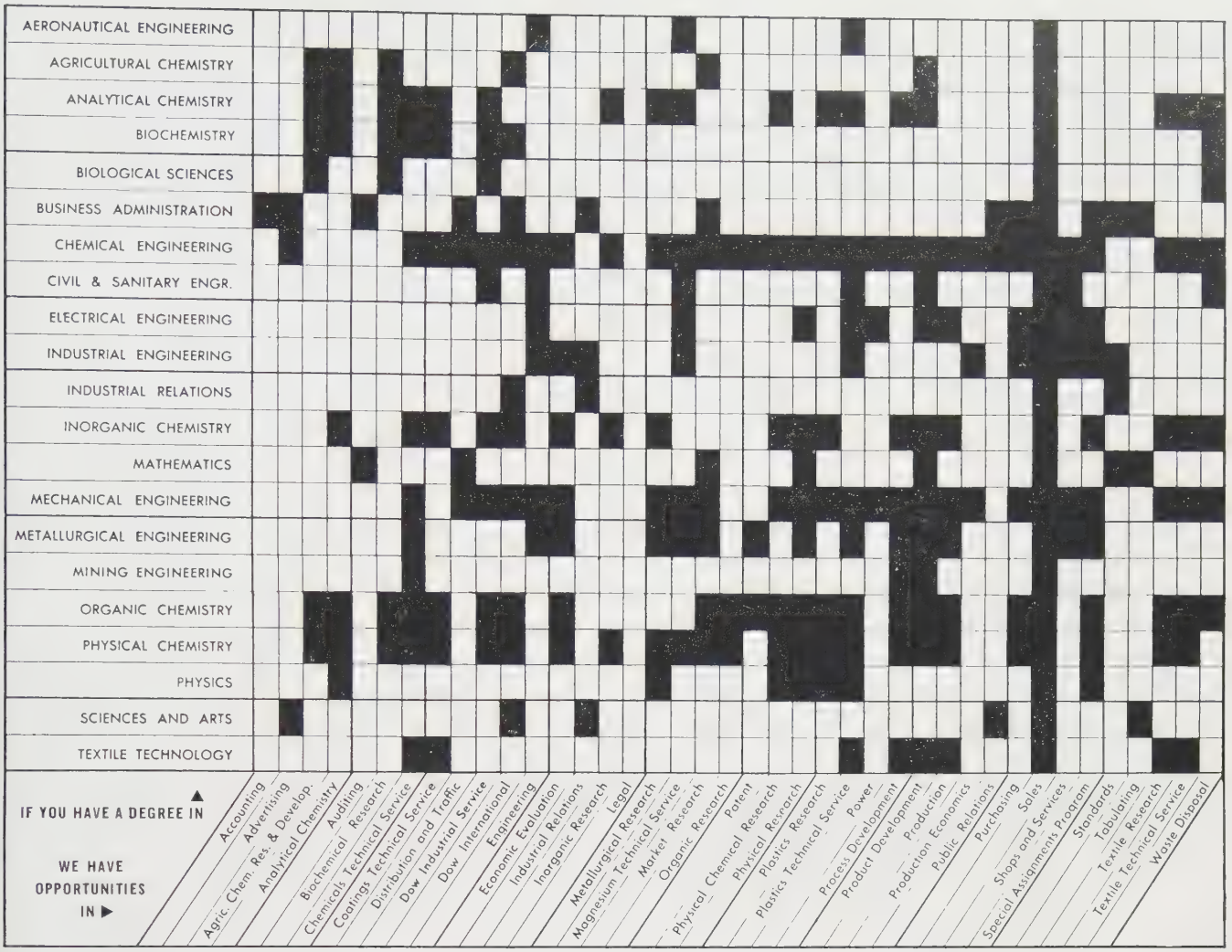

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AUTOMOTIVE SUSPENSION SYSTEM

By Dennis E. Lantz

One of the major factors in the expansion of this country in the last fifty years has been the development of fast, safe, economical transportation. Certainly the form of that transportation which is closest to the average person is the automobile and its big brother, the truck. Without these, many parts of our nation would be cut off from supplies, farm produce would never reach the market, and millions of people would be miles from their work, schools, shopping areas, and friends without any practical way to reach them.

The development of these cars and trucks on which the country depends so heavily has been a history of millions of man-hours spent in research, engineering, and application. Engines have become more powerful for their weight, more economical and infinitely more reliable. Gone, thankfully, are the days of hand-cranking, short engine life, and innumerable breakdowns, usually near either an illiterate blacksmith or no mechanic at all. Tires no longer blow out regularly every 100 miles, last but a few thousand miles, or need be pried off the wheel to make repairs. Long gone is unsynchronized "crash box" transmission, in which smooth shifts up and down were the result of either consumate skill or plain blind luck. Passenger cars are now capable of tremendous speed, with effortless driving and no worry of engine or tire failure. But they still bounce. And many of them get into serious trouble when pushing too hard around curves and turns. The suspension system bears the blame for these weaknesses, but even in its present state of imperfection is a great advance over fairly recent designs.

Basically, the suspension system is the complete arrangement of wheels, axles, springing media, shock dampers, and steering provisions under an automobile. Simply, the purpose of this array is to keep the car properly on the road, transmit the power or braking force from the tire tread to the chassis, and provide insulation from irregularities in the road surface for the occupants of the vehicle. It sounds fairly straight-forward stated in this way, and appears to be an easy job of design engineering. Is it? To claim it as "easy" within the hearing of any experienced automotive engineer would subject one to threats of sheer mayhem. Why is it such a difficult procedure?

As the first wheeled vehicles were two-wheeled carts, not planned for speed or comfort, the problem was solved by merely nailing or tying the axle to the cart bed. With the advent of bigger four-wheeled vehicles, it became necessary to aim the front pair around corners to cut down the resistance to moving the wagon out of a straight line. In this solution, the axle in front was merely fastened to a block which was pivoted from the bed. This method, known as "wagon steering," is used today only on simple vehicles for low-speed operation, such as farm and industrial carts and children's coaster wagons.

Instead of this fifth-wheel steering arrangement, the method used today is the divided-axle-system, invented by Lankensperger, in Munich, in 1817. The English patent on it was taken out by his agent, Rudolph Ackermann, and in all English-speaking countries it is still known as the Ackermann steering gear. Not only does it produce greater weight-distribution stability and less friction, but also much less tire scrub in cornering. This is due to a "trapeze" arrangement, in which the tie rod is shorter than the distance between the wheels, thus adjusting the turning angle to suit the turning radius of the separate wheels. Ideally, extensions of the front axles would intersect at a point on the line of axes of the rear wheels, and in practice this is met very closely, the geometry preventing this condition being exactly suited at any but one point.

Passenger comfort requirements quickly forced the early manufacturers to provide some form of springing system to cushion the shocks from the rough and rutted roads of that day. Over the years, as the automobile has become more and more vital to people, the public has demanded an ever-softer ride, often even when it entailed a serious loss of handling ability and control. By this time, most American manufacturers were using a beam type of rear axle, hung on leaf springs, and a beam front axle, also on leaf springs. Some form of friction damper was added at this time to cut down the repeated bouncing following a bump in the road surface.

Exactly what was it that this system was called upon to do? What are the factors influencing the design of suspension systems? Going back to the original requirements, it is necessary that the suspension guide the car on the road, transmit the accelerating or braking forces from the tire tread to the chassis and insulate the passengers and load from the tire tread to the chassis, and insulate the passengers and load from excessive road shock.

Passenger comfort demands some form of springing medium, and a device with a bounce-snubbing action to cut down on the continued pitching of the car after hitting a bump. In this respect, the springs should be as soft as possible, such that the occupants feel little disturbance. Unfortunately, if this is carried to extremes, the car will lean overly far if unbalanced in loading or when subjected to centripetal forces in a corner. Therefore, in the usual design configurations, the spring rate is chosen to fall between the extremes of the best handling and the softest ride. Recently with a number of new systems, it has

been found possible to get a very satisfactory ride without the usual penalty of loss in stability. The shock absorbers, also, are chosen on the basis of this compromise, stiffer sets being preferred on really roadworthy cars for their action in snubbing the bounces and keeping the wheels on the road where they belong.

In keeping the power flow from the wheel to the road, or vice-versa, a large number of considerations appear. As should be fairly obvious, it is necessary that the chosen tire keep its tread fairly flat and parallel with the road surface. As the frictional force is the product of the normal force (here the weight of the car) and the coefficient of friction, it is desirable that the weight on the tire remain reasonably constant. Should the vehicle develop excessive lean or side sway, the weight will be transferred to place a higher load on one side. This is best shown in a corner with the average car, where there is a great deal of lean to the outside of the corner. Further, the wheel linkage is such that there is a large lateral deflection under load, there will be excessive scrub on the tread, causing increased wear and possible loss of adhesion during hard manuevering.

Keeping the car in the proper attitude on the road is partially an extension to the factors explained above. In general, then, the problems involved are: keeping the wheels on the road; keeping the tires flat on the pavement; maintaining as little roll as possible; providing for the proper steering control; maintaining smooth power flow; achieving reasonable wear of all parts; and giving the maximum driver comfort.

Examining the two beam axles described above, such as were used on the majority of American cars for many years, it can be seen that they fell short of the ideal in many respects. At the rear, there are numerous difficulties, but only at a closer look do they become apparent.

Due to the fact that both wheels are on the same beam, any bump which is hit by one will be felt by the other. This can lead to some rather precarious situations when driving at a higher rate of speed over rough surfaces, or when striking a bump when going through a corner or turn. As another difficulty, consider the forces involved during a simple drive. Under acceleration, a twist is applied by the drive shaft to the differential, tending to lift the wheel on the side. The moment exerted by the tires on the pavement tends to rotate the axle and differential about a line through the centers of the wheels, causing "wind-up" in the leaf springs, and "hop" as they attempt to spring back. Further, the tires are forcing the rear axle forward, a thrust which must be transmitted to the car itself if the vehicle is to move. This entire load must be born by the axle connections to the leaf springs—then one goes into a turn—and hits a bump.

Even in straight driving at constant speed, the wheels must be located firmly, or there will be "rear-end steering" present as an added complication. The passengers demand that the whole affair be comfortable. It is a wonder, then, that cars are manageable at all, even with poor handling.

To tame this jungle of conflicting aims, a number of guide, control, and locating devices have been developed. Among these solutions are the torque tube, Watts linkage, radius rods, and torque arms—all merely remedies for a rather poor design arrangement in the first place. As for the need of such devices, it is well to note that they are to be found in stock car races, where handling quality is paramount. Unfortunately they do add to unsprung weight, that is, the weight which does not nest on the springs and thus bounces up and down with the rough spots in the road, adding a load to the shock absorbers and making the vehicle hard to handle.

The solution to this problem, then, is a rear suspension system with low unsprung weight, no transfer of shock from one wheel to the other, transfer of thrust from the wheels to the frame, and good locating of the wheels. There are several answers to this which are already known, all lumped under the name "independent rear suspension," and all with the possibility of being much better in action than the "live rear axle."

The first of these to be developed was the DeDion system. Using this method, the differential is bolted to the frame, thus cutting down on unsprung weight, with the driving torque going to the wheels through short half-axles. These feature a universal joint at each end, and carry no load other than the torque fed to the wheels. Some form of springing, usually coil springs, is mounted at the wheels, which are tied together by a beam bent around the differential and bolted to each. This beam is located by a vertically sliding pillar in the center, or possibly a Watts straight line linkage which accomplishes the same effect.

The advantages are many. There is no torque reaction between drive shaft and differential which is transmitted to the wheels, because the differential is bolted to the frame. Fastened to their connecting beam, the wheels stay perfectly parallel to the road, and are well located. The arrangement tends to have a high roll center, which means that it will tend to roll more nearly about the center of gravity. In this way, there will be less lean and weight transfer in cornering, resulting in better stability at speed.

Unfortunately, the saving in unsprung weight is moderate, due to the connecting beam, which also transmits road shock from one wheel to the other. Then too, the beam and wheel group have unfortunate tendencies in the realm of vibration control, the high polar moment causing most of the difficulties with low-frequency resonance.

Another solution, more widely used, is the swing axle system, as typified by the very popular Renault Dauphine, Corvair, and the Volkswagen. Here, the arrangement is much like the DeDion, except that there is no connecting bar between the two wheels, and all locating and force transmittal is handled at the wheels. The usual method of doing this is with a trailing link arrangement, essentially two parallel bars fastened at the front to the frame, and at the rear to the wheel carrier. This lends itself to torsion bar springing, but coils are also used.

By this method, unsprung weight is very low. There is no shock transfer between the wheels, and the torque reaction is eliminated. Unfortunately, there may be some problems in the wear on the mechanism involved, though most manufacturers have had no trouble here. The biggest difficulty seems to be that the roll center gets too high, causing some handling problems, but this has been solved on such cars as the German Porsche, which is the top contender in its class in road racing.

Another way out of the roll-center problem is the use of a low-pivot swing axle, as used on the latest Mercedes-Benz automobiles. This pivots the axle carriers below the differential and adds a spring at the pivot for stiffness. Thus the roll center is lowered and roll stiffness increased, the latter without making the main springs firmer and the ride harsher. It cuts rear-end steering, keeps the wheels on the road, and in general, behaves as a rear suspension system is meant to. In all likelihood, the great advantages in handling provided will bring about its adoption, despite an increase in cost and complexity.

At the front, the situation at present on American cars is a somewhat sunnier picture. The completely inadequate beam axle mentioned before died in 1948 on the Ford, and a lingering death it was for such a poor design solution. The roll, vibration, shock transfer, wheel locating, and unsprung weight characteristics render the system suitable only for the wagons on which it replaced the fifth-wheel method. At speed, or in hard cornering, the only remedy is an independent arrangement.

(Continued on Page 41)

Disposal of Radioactive Waste

By Lawrence Luther

A heated argument now exists between various groups of people concerning the dangers of radiation due to radioactive waste. Radioactive waste may be defined as the "hot garbage" from "dirty" fission in the form of gases, liquids, and solids, ranging from contaminated protective clothing to heavy chunks from the heart of reactors. Two-thirds of this waste is classified as low-level and short-lived while the other one-third is high-level and long-lived. [1]Needless to say, the high-level is very radioactive. Almost all high-level waste is in a liquid form and this is the topic of this article.

This is not a day to day problem but a cumulative one in which the problem becomes more serious with the passing years. By the year 2000, the United States will have accumulated 50,000,000 gallons a year of high level waste. This will be composed of

Cesium 137	5.3×10^9 curies
Strontium 90	6.09×10^9 curies
Promethium 147	6.07×10^9 curies
Cerium 144	1.013×10^{10} curies
Americium 242	1.1×10^6 curies
Curium 242	3.3×10^6 curies[2]

where a curie is a unit of mass of radium emanation.[2] These figures can be compared to the amount of radiation that a standard man can absorb which is about 1×10^7 curies[4]. The total radiation listed on the preceding page has the potential of killing 2.8×10^{13} people which is many times over the population present on the earth today.

To solve the above problem, safe ways to dispose of radioactive waste must be discovered. At the present time, the United States is disposing of its waste in three different ways.

The first method is that of the storage of radioactive waste in stainless-steel tanks. These tanks are surrounded by costly refrigeration coils which keep the long-lived isotopes below the boiling point until they decay. The normal life span of these storage tanks is about 100 years but this is a relative small figure when compared with the half-life of the high-level isotopes which is approximately 500 years. Tests have also proven that 1 out of 3400 of these tanks fail within a few years after construction. Failures would be accidental and disastrous. This method is classified as an interim method but may have to become permanent if better methods cannot be found[5].

The second method of disposal is called shallow ground disposal. This system is used for the medium-level waste. The waste is run into shallow pits dug in the surface soil. As the waste soaks down, it pushes ahead of it much of the natural soil moisture and takes its place in the pores of the sand. It is necessary to exceed the permanent holding capacity of the pores, at least in the upper part of the earth column, in order to get the waste to move, and the earth column will continue to drain for a very long time after feed to the top is ended. The basic trouble in this method of disposal is that there has to be room for the waste to stop above the water table so that the waste will not get into a water supply. This method is cheap and simple but the margin of safety of the operation cannot be determined. It is much too easy for the waste to contact underground water supplies.

The third method is known as off-shore dumping where the radioactive waste is packaged on shore and then dumped in the ocean. The waste is placed in a steel container which is encased in concrete.[7]

The Crossroads Marine Disposal Corporation which was founded in 1946 is the sole dumper of waste.[8] This corporation does the packing and then dumps the radioactive waste 220 miles off the City of Boston in 6000 feet of water. They use to dump only 12 miles off-shore but were made to dump it farther by orders of the Court.[9] It was thought before that this waste could be dropped in the deep trenches of the Atlantic and Pacific Oceans because of the lack of current flow. The depth in these trenches is from 6 to 7 miles. A Soviet Professor, P. A. Moiseev, has objected to disposal into the sea. Considering both biological and physical transport to waste products, he came to the conclusion that radioactive waste emerging from a container at very great depths does not stay localized but will mix rapidly and will finally be brought to the surface waters[10]. This conclusion was affirmed by deep sea explorations in the Tolliver Trench off the island of Guam. Considering this third method, it has been shown that off-shore dumping can be only used as a temporary measure until the year 2000. By this time it is hoped that the United States will have nice, clean fission power.

Because of the growing importance of atomic power, future disposal will be of the utmost importance. One of the best of the proposed methods is the use of abandoned limestone mines for waste storage. These mines are very sturdy and will not fail like coal or metal mines. Because of the way that they were formerly used, trucks or railway cars can usually run directly into them. These limestone mines are always overlain by shale which will keep out the water thereby keeping solid waste very dry. Because of these points, a major disaster could probably never happen. The most serious drawback to this method appears to be the cost of converting liquid waste to a solid form which is very high.[11]

An experiment now being carried out at Oak Ridge and the University of Texas concerning the disposal of radioactive waste in salt beds is proving to be very successful. In this process a hole is drilled approximately 1000 feet into the ground in a salt bed. A pipe is

(Continued on Page 41)

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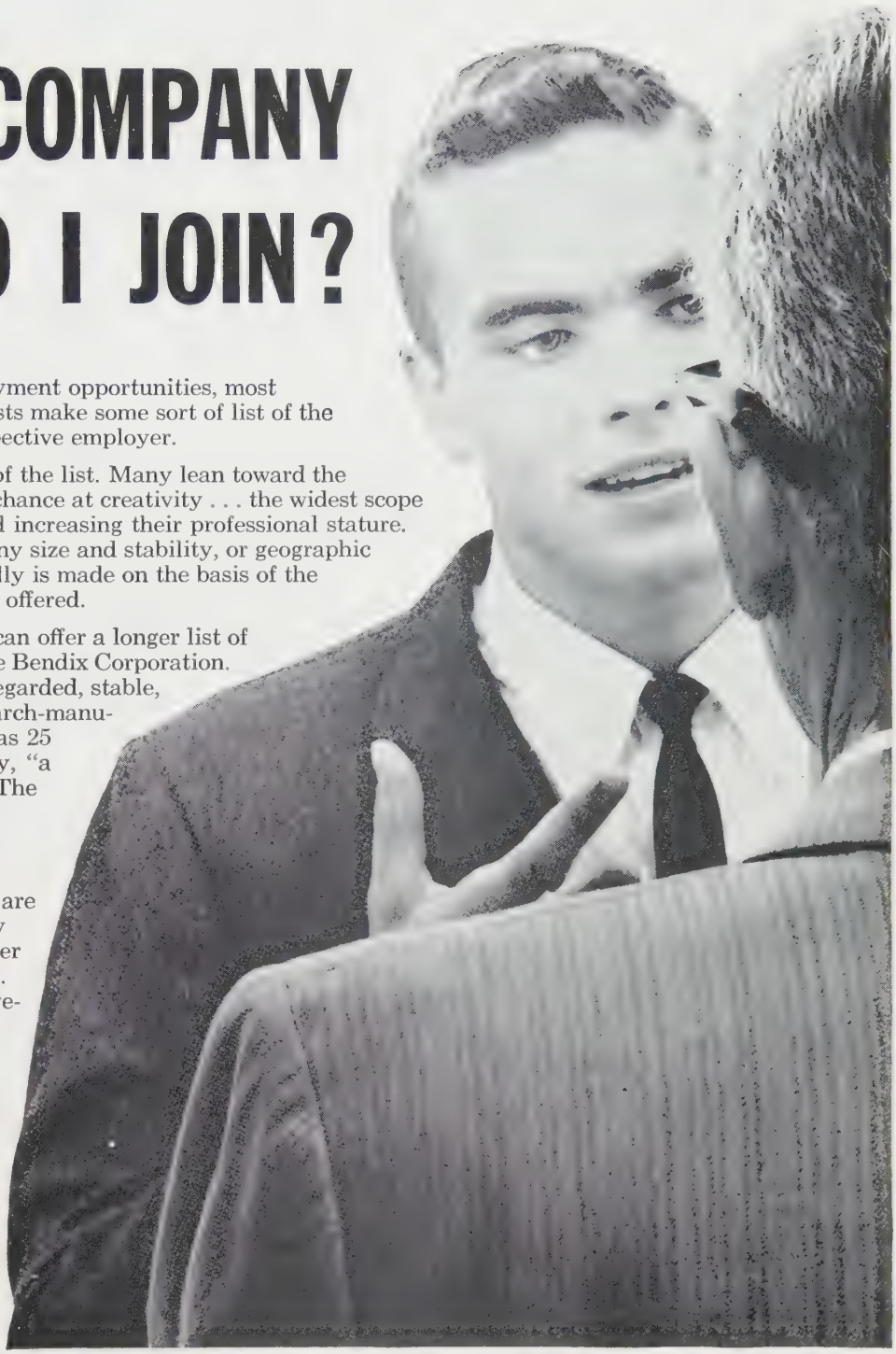

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A MIRROR FOR THE PROFESSIONAL ENGINEER

By William A. DeLorme

America has two stout bulwarks against the all-too-real Communist threat which is spreading like a cancer and threatening to engulf the world. The first is the respect for the individual which is intrinsic to our Judaeo-Christian heritage. The second is the material security of a large middle class, a product of our highly productive technology.

By his creative genius and knowledge of physical laws, the American engineer has harnessed nature's energy and molded the elements of the earth to fit the requirements of our mass-productive society.

However this achievement is by its very nature a two-edged sword. Although our technology is our greatest physical asset as a nation, it is also the greatest moral danger to us as individuals. It seems to be a fundamental law of nature that political apathy follows in the wake of materialism. It was this apathy of the individual towards his political responsibilities that placed the ancient Democracy of Athens and the Republic of Rome in the tyrant's and invader's hands.

We are deeply indebted to the Greeks who formulated self-government, and especially to ancient Athens where the citizen's personal responsibility to see that government worked for the people was fully recognized in Solon's code of laws.

But the echoes of the heroes of Thermopylae and Solon's code as a living Greek heritage were hushed to an indiscernable whisper during the closing hours of the Greek City States. In the same manner the early Roman would not have recognized his Caesarian counterpart who had bargained away his individual political rights for State support and a seat at the Roman circus. Thus the true greatness of Rome evaporated in the political intrigues and moral degeneration of the Senate.

As Emerson once said, "This country was founded by the bold and cannot be maintained by the timid." He might well have been speaking of Greece or Rome.

We have thus arrived at an apparent paradox of our time, and like a small boy whose clenched fist is stuck fast in the neck of the candy jar, must look for a solution. The solution is not a "big brother" government, but lies within ourselves. The seed of our destruction as a free individualistic society lies within us. A people that shall not be conquered is composed of individuals that will not be conquered.

Our problem therefore resolves itself into keeping our individual freedom while maintaining our material security. This seeming contradiction of goals can only be met by active individual participation in the responsibility of government. Our government at all levels, federal, state, and local, must be a living organ truly reflecting the sum of all its individual citizens.

It is not enough, therefore, for us as engineers to concern ourselves solely with advancing our technology. Our society has given us the benefit of a college education, thereby preparing us for potential leadership. Our personal responsibility as professional men demands that we repay this debt not simply by serving our society as engineers, but also by meeting the higher ideals and responsibility of our status and by participating vigorously and sincerely in the political structure of our country.

We are engineers by education—we are professional engineers by choice. Yes, we have the freedom of choice not to act—to let George do it—to succumb to the Lorelei's song. All to easily we can sit back and take a cynical or apathetic position towards the passing parade of government. This choice becomes even easier as the government becomes bigger. If we don't grow too, our government will soon become foreign and remote to our understanding. Then a cool contempt will set in. We may falter at the massive labyrinth of bureaucracy; confused, we may dismiss our responsibility with apathy and time-frayed rationalizations. We must not fool ourselves, though, into mistaking apathy for reality. This is our greatest danger: apathy is a timeworn path of history—the path sauntered by the Greeks and later plodded by the Romans.

We must not underestimate the influence that we as individuals, especially as educated and trained men, can exert for the benefit of all. We must realize and accept the personal responsibility that each of us has to strengthen and preserve our country both materially and politically. In turn, a free acceptance of this responsibility will help to build a public interest in "part-time" politics that will restore to us our full heritage of self-government.

Turn your eyes on the mirror of history. Can you still hear the echoes of our past? Do you hear the trumpet calls: " . . . have already hallowed this ground," "Give me liberty . . . ", "When in the course of human events . . . " Or have we begun an ignoble entrance into Huxley's *Brave New World.*

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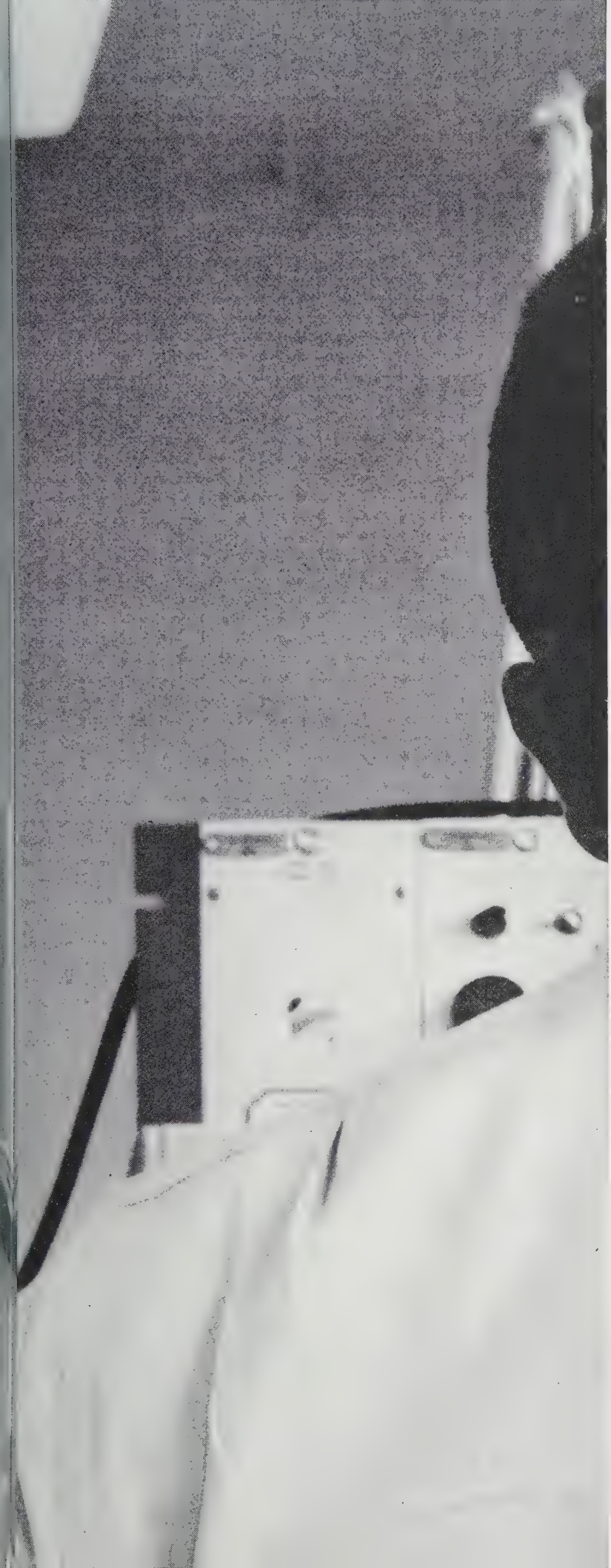

Harley A. Cloud (B.S.E.E., Penn State '58) is a group leader in the development of simulation testing equipment for a new airborne computer which IBM is building for the Air Force.

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Without the airplane leaving the ground, his testing equipment will simulate such inputs to the computer as acceleration in the inertial system, velocity in the doppler radar, and air pressure in the air data subsystem. These simulation techniques will help protect lead time for the entire project.

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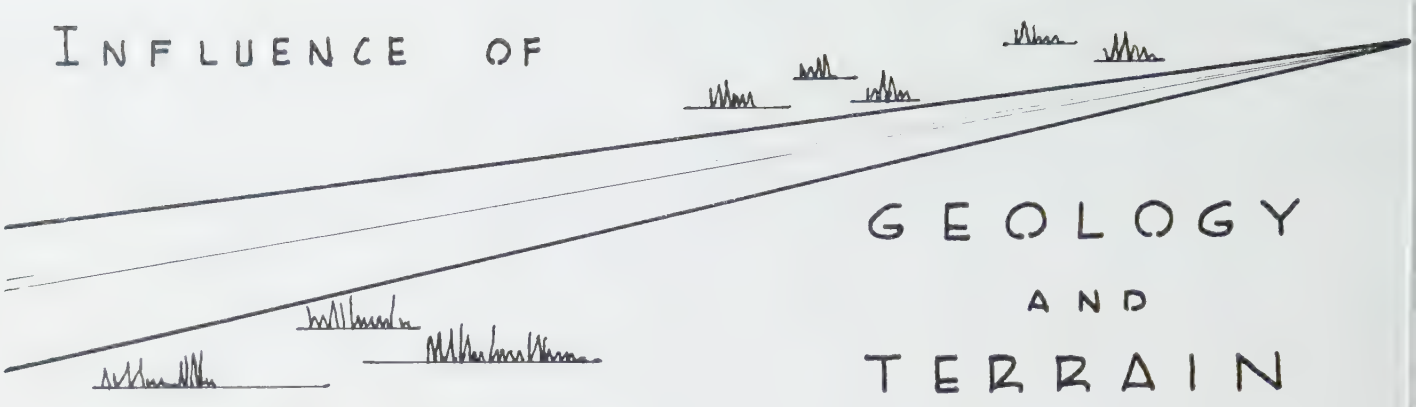

INFLUENCE OF GEOLOGY AND TERRAIN ON MODERN HIGHWAY ROUTES

By Dennis L. Steinback

Since the time of the Roman Empire, the construction of transportation routes has been greatly affected by the geology and terrain of the surrounding area. Roman roads followed natural routes determine by the geology of the local land—through valleys, along rivers, and over hills. The Julier Pass Road through the Alps, which is still in existence, is one of the best examples of Roman construction. It has fewer zigzags and less wind exposure than most modern roads built in similar terrain. Thus it has less maintenance trouble.

Early pioncer roads and the first canals built in America conformed to local topography and geology to make construction easier and to maintain suitable water levels for canals. The first seaports weren't created by man, but grew up around the sheltered mouth of a river or a naturally enclosed body of water.

It wasn't until the coming of the railroads in the early 19th century that the practice of merely following the limitations of nature for location of transportation routes was changed.[3] Cross continent tracks had to take the shortest possible distances between stations. Tunnels were built to go through mountains and bridges to cross rivers. Up to this time roads wound around hills and mountains and led to the shallowest parts of rivers where travelers could ford the river.

Only in the last two decades has the progress of highway construction been comparable to that of railroads in this engineering aspect. Today, especially, the application of geology in highway engineering is unique in both the fields of design and construction. It is this application that has led to some of the most notable structures in the transportation field — because of the great engineering feats required — and to new and improved procedures in the planning, construction, and maintenance of today's highways.

The location of the route of the highway is a main factor in the progress in the physical structure of modern highways. Toll roads and expressways have been partly responsible for this progress. The locations of these roads have demanded remarkable structures in order to meet the exacting standards set for them.

The Alcan Highway, built in 1942 as a military supply route, is a notable engineering feat due to its location in a snow and ice covered terrain.

In 1960 Canada completed the construction of its 4,470 mile, coast to coast, paved, Trans-Canada Highway. The location of this highway from Newfoundland through the many national forests, and over the Rocky Mountains to the west coast of British Columbia, will make it an outstanding engineering accomplishment. Along the road one can find many bridges, as well as earth fills of up to 200 feet in depth and cuts of 175 feet, that were needed to construct the road foundation.

Many notable bridges and tunnels have been and are being built to enable roads to connect cities separated by rivers or mountainous regions. French and Italian engineers are in the process of constructing a highway tunnel through Mont Blanc, the highest peak in the Alps, which will be 39,032 feet long, the sixth longest in the world. The two lane tunnel will be 27 feet, 10 inches wide and 22 feet, 8 inches high.

On Lake Okanagan in British Columbia, Canada, the first floating bridge to be built in North America in twenty years was recently completed.[2] The bridge was built to connect two cities across a narrow part of the lake. At first a suspension bridge was thought to be the logical type of structure, but further investigation showed that the subsoil on one side of the lake was nothing but silt and unconsolidated clay. Thus there was no way of building a foundation for a suspension bridge on this side. Since a bridge had to be built, engineers decided to use a floating structure.

The bridge, which is 3,000 feet long with a span of 2,885 feet, floats on twelve concrete pontoons—two transition pontoons and ten main pontoons under the span. Each main pontoon is 200 feet long, 50 feet wide, and made up of fifty-six hollow cells 15 feet deep. Each pontoon is anchored by two hoe shaped anchors weighing seventy-five tons each. The anchors were buried into the lake bottom from 25 to 35 feet deep by the use of water jets that pushed the soil aside as the anchors were lowered. Since the water level in Lake Okanagan is controllable within a four foot range no problem with misalignment of the road and bridge are involved. When this bridge was put into operation in the summer of 1959, it was called one of the most remarkable engineering projects in Canada's history.

Local terrain affects not only the actual structure of a highway, but also forces the development of new and improved procedures of planning, construction, and maintenance of the highways. In planning of the location of new roads, forests, mountains, ice, and snow made the initial surveying difficult and expensive if done on the ground. Thus the use of aerial photography has made possible the coverage of much of this land.

Air photo's originally helped only in the route delineation on their unscaled photographs. Today, however, the air photograph is so precise and accurate that ground reconnaissance and location

hay tend to become obscure.[3] The results of a test in West Virginia proved hat whenever "a ground formation was f sufficient extent to be of significance o highway engineering it could be de-rmined" and its boundaries set.[1] Subils such as shale and sandstone were sily recognized and their boundaries cated by air photos. To a highway enneer an air photo is an accurate rec-d of the physical features of the rth's surface

The local terrain is oftentimes a hallenge to construction methods, and he solutions to the problems usually re-lt in new or improved procedures. An xample is the one faced by the Trans-anada highway construction over uskeg. Muskeg is an organic growth ound in cold northern climates that oks compact, firm, and green, but ctually can contain up to 1500% moisure content.[3] It is impossible to drain y ordinary methods. To add to the roblem, under most muskeg bogs the il is in a condition called permafrost. his ground is permanently frozen olid, but if the muskeg is removed, the round thaws and becomes like soup.

In order to have the ground remain ard enough to support foundation footngs, either a shallow muskeg deposit ust be left to control the depth of awing of the permafrost in the sumer or the ground must be filled. A ethod used in the Trans-Canada ghway construction is underfill blastng. Fill is placed across the bog and llowed to settle. Holes are then dug nderneath the fill and explosives set. he explosives blow the muskeg out rom underneath the fill allowing it to ttle on top of the firm fill. Muskeg ogs up to thirty feet deep have been uccessfully displaced by this method.

In highway construction the supply f aggregate for the roadbed is an imortant consideration. In most of North merica the area near a construction te contains in its geological structure n abundance of aggregate. However, parts of Canada, especially Newundland, and in many tropical counries supplies of aggregate are not availble. This scarcity has led to the manucturing of it at the site of the road. n Newfoundland rock was quarried nd crushed for the Trans-Canada ighway.

In tropical countries there is found ne of the most troublesome soils for ighway construction. This soil, called black cotton" soil, contains no aggregate deposits and is not firm enough s it is found in nature for road beds. after much study it was found that the il if burned in place and then broken would form a coarse aggregate. This se of the soil in its natural site is beoming more and more important.

The effect of the surrounding area on a highway is not ended with the construction. Local geology also plays an important part in road maintenance. The obvious problem is drainage of the roadbed, but in certain areas such problems as rock slides, landslides, and snow slides must be guarded against. Several places in the United States are using electrically actuated warning fences near the highways in places of frequent rock slides. These fences are used to warn the highway maintenance crews of slides as well as for stopping the rock slides.

A similar problem is that of snow slides. The Trans-Canada Highway is especially faced with this problem because of its location. Where the highway passes through the Canadian Rockies in Glacier National Park, the yearly snowfall averages over 600 inches in a year. The road has to be protected from the danger of the great snow slides. Two new methods are being tried at the present to keep these slides away from the highway. Large staggered earth mounds are being built in the paths of the usual slides to try to keep them from reaching the highway. Also large ledges are being cut in the sides of the mountains slanting in directions away from the highway areas. These snow benches act as artificial snow slide paths to carry the snow away from the roads.

As civilization spreads, transportation routes become more and more important. Especially in the improvement of the present underdeveloped countries of the world is road construction necessary. With the need for new and improved highways, the affects of the local terrain and geology on the highways also become more important. As men learn to apply knowledge of terrain to their engineering, the effects become more notable in the remarkable structures. and in the procedures of building and maintaining these structures. The influence of geology and local terrain on highways certainly can be seen in today's modern roads.

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The Permanent Glamour of Engineering

Isn't it strange when so many young people are looking for glamorous jobs that engineering, the most glamorous profession on earth, should be shorthanded?

Could it be that engineers don't look objectively at themselves and that they take for granted their tremendous accomplishments at which others marvel? Engineers are the men who have put their practical mark on almost everything useful in life. No profession has contributed a greater wealth of material accomplishments for the betterment of mankind. It has been the engineers who have put in the big licks that have changed and improved the world. They are the leaders of the Twentieth Century.

Certainly, some people call our time the Age of Chemistry, the Age of the Atom, The Age of Glass, the Age of Petrochemicals or the Age of You-Name-It. Put them all together and you have the AGE OF ENGINEERING.

Much of the permanent glamour of our time is wrapped up in engineering. The dictionary defines "glamour" as "Magic, a spell or charm." A truer definition was never writ, for verily engineering has wrought the magic of our time. Indeed, the dictionary might well add "engineering" as another synonym for glamour.

There is no hum-drum job to an engineer, because engineering is creative, the most glamorous feet-on-the-ground head-in-the-clouds profession on earth. Glamour is where you find it. And you will find it in every engineering office or department—if only you look for it!

Nuclear Rocket Could Increase Payload

Development of a nuclear rocket to operate in conjunction with already planned space programs could increase United States payload capability two to three times, John W. Simpson, Westinghouse Electric Corporation vice president, told members of a congressional committee on March 1.

Testifying before the House Science and Astronautics Committee, the executive in charge of the company's atomic power department and astronuclear laboratory stated that adding a nuclear upper stage to Saturn would double or triple the payloads we can put into orbit prior to 1970. This early capability is not only important during this critical decade in our international affairs but it will also build the base for the period after 1970, when nuclear rockets will dominate space propulsion.

AIRCRAFT WARNING and CONTROL SYSTEMS

By V. Mandarino

As aircraft grow more complex, it is essential that operation of the aircraft for the air crew and passengers remain simple and safe. To effect simplicity for the air crew and passengers, there are many electrical circuits which control or operate motors, hydraulic systems, pneumatic systems, heating systems, etc. These units or systems operate whenever the pilot closes a switch. Many of these systems will perform their function automatically relieving the pilot of all responsibility.

The aircraft, to be as effective and safe as possible, has many warning circuits incorporated in its systems. These warning circuits will indicate by a vis- normal operation of the unit, failure of a system, or unsafe condition in the ing circuit may mean the difference in a successfully completed flight or a crash aircraft.

The object of this article will be to familiarize the reader with a few of the many warning and control systems used on some typical aircraft. Since each aircraft has its own unique systems, a few of the simpler systems of a selected group will be chosen. The ones selected are typical and will convey the idea to you.

In presenting the material, I will choose military aircraft as a matter of interest; however, the same systems apply to commercial aircraft as well.

The sequence of events will be presented as they would occur on a typical bombing mission. This will consist of take off, in flight, and landing, in order.

When looking into a wheel well, under the cowling, or under an inspection plate on an aircraft, a maze of wires is presented. Some of these wires are part of complicated systems; however, many would be involved in a number of important but simple systems. The word "simple" stems from the fact that many of the circuits presented are basically simple even though they may have many yards of wire in them with a number of sequencing relays incorporated.

Take Off

To insure a safe takeoff there are a number of systems that aid in a safe operation. Of the most important is a system that warns the pilot that the wheels are not down and locked. During an inspection or repair of a landing gear, it may have been necessary to jack the plane up and tamper with its control mechanism. It may be possible that the mechanic let the gear back down but forgot to check to see if it was locked in place. With the down-locked warning system the pilot can quickly see that the gears are not down and locked which may lead to a collapse of a gear as he speeds down the runway.

The next system incorporated in takeoff is the cowel flap warning system. The purpose of this system is to warn the pilot of an unsafe position of the cowel flaps. For example, if the flaps were open too far, they would cause an unwanted drag that may hinder a successful take off. This situation could prove disastrous with a load of bombs.

Some aircraft have door-closed warning systems which are used to warn of an unsafe position of doors. These doors would include bombay doors and landing gear doors. These door circuits are simple circuits through a red light that would receive power if the door-close switches were closed.

In Flight

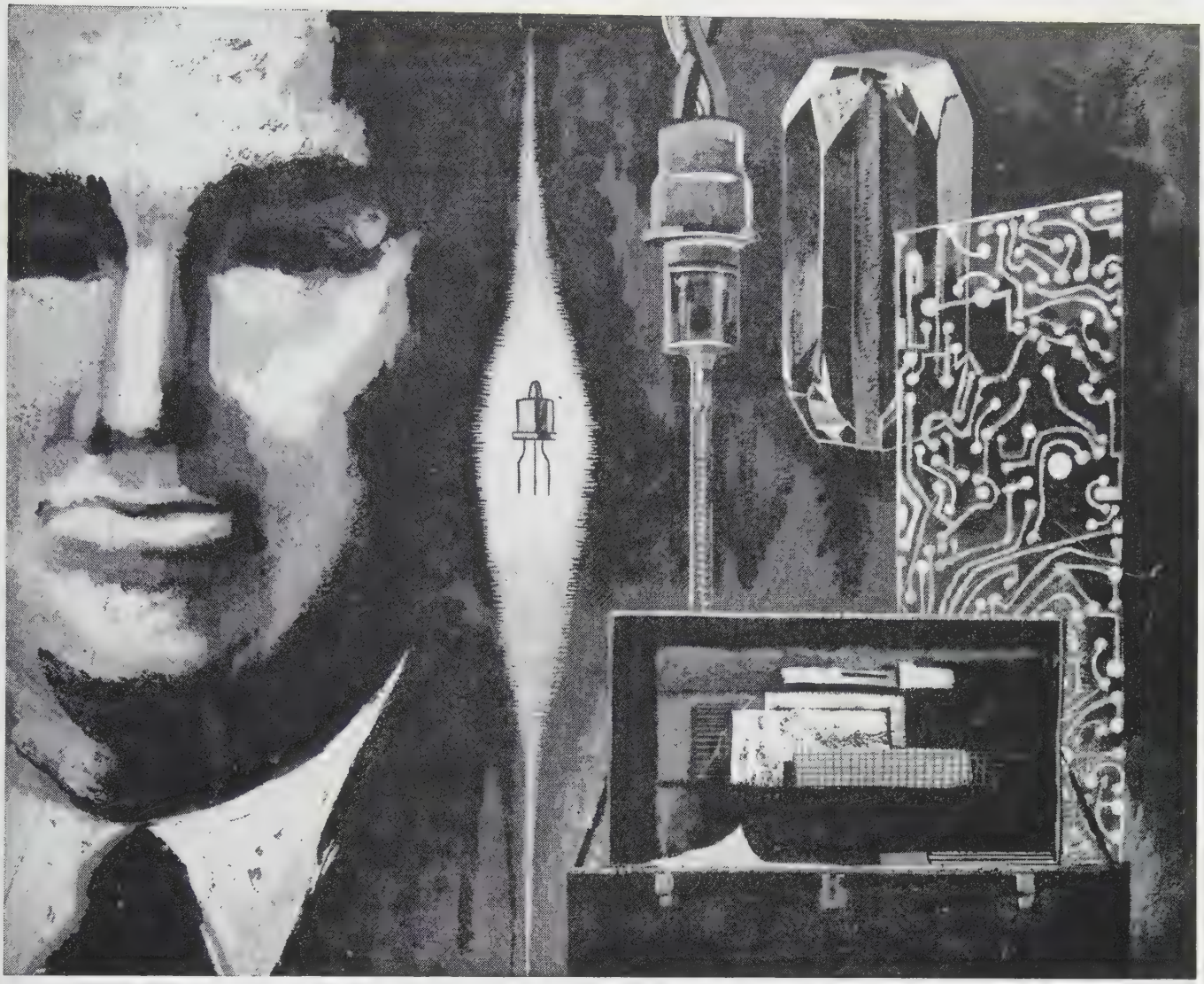
During a flight there are numerous things that can be accounted for by automatic means. Since most difficulties that could occur would prove disastrous. In most cases it is an advantage to have them checked automatically instead of depending upon human memory. A system of importance is the fuel pressure indicator. This system incorpates a pressure switch which is in series with a red light. The light is in the pilot's compartment. When th switch is actuated by a low pressur the light in the cockpit goes on, warn ing the pilot of the danger. This sy tem is also incorporated in heater g lines to notify of the lack of fuel to th heating system.

An important system in flight is th cabin pressure warning system, whic notifies the crew of the altitude. An e perience of high altitude without ox gen certainly points out the importan of this system. Because of the gradu variation pressure, the effects are grad al and the need for oxygen is imperce tible until it is almost too late. Usuall lack of oxygen makes one very wea and makes it difficult to move the arm and legs. The cabine pressure warnin system consists of an evaculated bello switch, set at sea level pressure; as al tude is increased, the switch slow closes until at about 10,000 feet, it act ates a warning horn to inform the cre of the danger. This system is very us ful when flying with oxygen mask since the masks are not used until high altitude is reached.

Another system of importance is t fire warning system. This system is us to detect and warn the crew of a fir The fire could be on the air craft or the airplaine engine. Various systems a employed, most of which are basical thermocouples connected to indicat lights. Some systems have an automa extinguishing control which attempts put the fire out as it starts. In any eve the crew will be notified as soon as t fire starts.

Another interesting system is t smoke detector. This system indicat the probability of fire because of t smoke instead of the heat. In this syste photo-electric cells are used as indic tors. This system is usually used larger aircraft in baggage or freig compartments. Periodic inspectio should be made of this system to insu

(Continued on Page 48)



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Technocutie . . .

JONI KACMAR

Joni Kacmar, our techno cutie for October, is we under way to realizing he ambition of being a mode She has been an Illio finalis Miss Press Photographe finalist, and Miss Cham paign County Fair finalis Acting also strikes her fanc as can be seen by her wor in the University Theatr Just for kicks she's also stunt show this year.

Dancing has long bee her favorite hobby. H twelve years of dancing e perience include teachin and choreography.

This summer she worke in the Electrical Engineerin Research Laboratory biolog cal computer group for D Von Foerster, assisting in r search on self-organizin systems.

Now a senior in eleme tary education, she is pra tice teaching in the four grade at Lincoln Grad School in Champaign. Th 21 year old blond has blu eyes, is five feet four and half inches tall, and weig one hundred and te pounds. Her other vital st tistics are 34-22-34.

•

Photos by Lynn Kesler

What does Olin do for a living?

A lot of things. Some of them might surprise you. Read this.

Olin conceives new products at a rate of no less than one a week. Some appear under our own name. Others bring fame to our customers.

Did you know that Olin pioneered liquid chlorine and synthetic ammonia in the U.S.? Is a leader in agricultural chemicals and synthetic detergent builders? Makes the hydrazine derivatives used as missile fuels? Some of the work of our **CHEMICALS DIVISION**

Common clay is now anything but "common." In the lab, we recently developed an economical process to convert clay into—of all things—alumina. Stronger metals, new alloys, and metal sources that would have made alchemists scoff in disbelief, are now being pioneered by our **METALS DIVISION**

Our organic intermediates—those polysyllabic tongue twisters only chemists can pronounce easily—are used in the manufacture of many new "wonder" plastics. We recently developed smokeless Ball Powder® with many immediate uses, and many more astonishing potentials. New and better explosives, detonators and blasting caps are challenges in Olin's **ORGANICS DIVISION**

Our research teams are probing for new films to keep foods fresh longer. We work with packaging materials from cellophane to kraft paper, corrugated boxes to lumber. The seemingly incongruous quests for crisper potato chips, lighter weight printing papers and more effective cigarette filters are all part of Olin's **PACKAGING DIVISION**

In the very research center where penicillin was first crystallized, scientists now probe for a B_{12} antagonist to arrest cancer. On any given day, 150 of our drugs or new dosages may be undergoing clinical tests throughout the world. From Olin's **SQUIBB DIVISION**

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. . . Probing new methods of energy conversion, such as magneto-hydrodynamics?

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HOWARD HUGHES DOCTORAL FELLOWSHIPS. If you are interested in studies leading to a doctor's degree in physics or engineering, you are invited to apply for one of the several new awards in 1962 on the Howard Hughes Doctoral Fellowship Program.

This unique program offers the doctoral candidate the optimum combination of high-level study at an outstanding institution plus practical industrial experience in the Hughes laboratories.

Each Howard Hughes Doctoral Fellowship usually provides about $8,000 annually. Of this amount approximately $1,800 is for tuition, thesis and research expenses, other academic fees and books. The remainder is composed of salary earned by the fellow and a stipend.

Howard Hughes Doctoral Fellowships are open to outstanding students. A master's degree, or equivalent graduate work, is essential before beginning the Fellowship Program.

HUGHES MASTERS FELLOWSHIPS. The Hughes Masters Fellowship Program offers unusual opportunities for education leading to a master's degree . . . and, in addition, provides each fellow with practical experience in the professional field of his choice.

Approximately fifty new awards will be made in 1962 to qualified applicants possessing a bachelor's degree in engineering or physics.

Most of the award winners will be assigned to the **WORK STUDY PROGRAM** and will attend a university sufficiently near a facility of the Hughes Aircraft Company to permit them to obtain practical experience in a professional field of their choice, by working at the company at least half time. An appropriate stipend will be awarded.

A small, highly selected group will be offered a **FULL-STUD PROGRAM.** Participants in this program will receive fellowships tha permit them to attend an outstanding university on a full-time basi during the regular academic year with a substantial stipend.

After completion of the Master's Program, fellows are eligible t apply for HUGHES STAFF DOCTORAL FELLOWSHIPS.

For both programs, typical areas of research and development t which fellows may be assigned while working for Hughes include weapons control systems, infrared search and track systems advanced propulsion systems . . . parametric amplifiers, masers lasers, microwave tubes and devices, electron-tube and solid-stat displays, semiconductor materials, antenna arrays, aerospac vehicles and trajectories . . . plasma electronics; solid-state, atomi nuclear and aerospace physics; propagation, mechanics of stru tures, chemistry and metallurgy . . . systems analysis, human factor and analysis, network analysis and synthesis . . . microminiaturiz tion, communications, date processing, information theor simulation.

The classified nature of work at Hughes makes American citizenshi and eligibility for security clearance a requirement.

Closing date for applications: January 15, 1962.

How to apply: To apply for either the Howard Hughes Doctor Fellowship or the Hughes Masters Fellowships write Dr. C. Warfield, Manager Educational Relations, Hughes Aircraft Compan Culver City, California.

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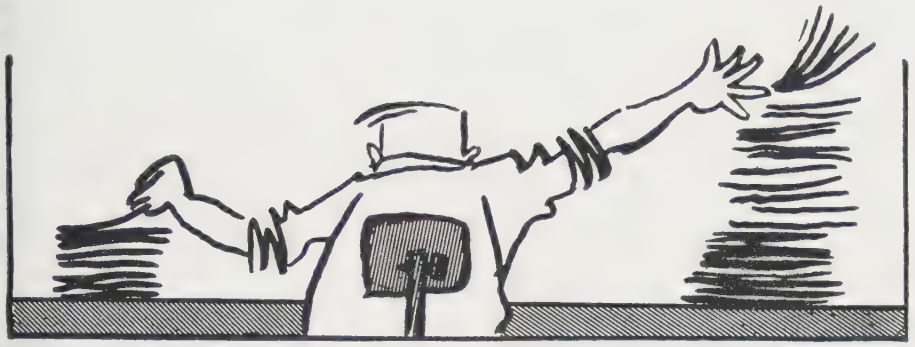

Edited by Wally Cwik

An American in Brazil

Despite the language barrier and a shortage of teaching aids, Professor Linn Helander of Manhattan, Kansas, is making considerable headway in his efforts to establish an advanced engineering problem at the Aeronautical Institute of Technology, in Brazil.

Professor Helander, former head of the mechanical engineering department at Kansas State College of Agriculture and Applied Science, is working under a contract with the U. S. International Cooperation Administration.

His assignment is to introduce and teach a course in heat transfer, train two men to teach the course when he leaves and assist on matters related to the institute's curriculum.

In his first annual report, recently submitted to ICA headquarters in Washington, Professor Helander stated the course on heat transfer has been taught for one semester and successfully completed by five students "with a level of achievement comparable to that which would be expected of students with somewhat above-average competence in our schools in the States."

Professor Helander went into considerable detail on the difficulties he has encountered with the language barrier and the lack of teaching aids.

"During all but the last week of the semester," he said, "only one text book was available to the five students in my class. Because of this, I found it necessary to do more lecturing than otherwise would have been wise. . . . Because of my lack of proficiency in Portuguese, I gave my lectures in English. Each lecture was translated into Portuguese by Professor Quintella (the man who has been trained to take over the course) and given to the students, normally at the end of the lecture period but on two or three occasions at the beginning of the following period."

In general, Professor Helander regards the lack of a graduate school as the biggest deterrent to the institute's aims.

"Because of the low salaries paid to Brazilian professors at this institution . . . and the present lack of a graduate program, the recruiting of staff is difficult," he said.

In an over-all evaluation, Professor Helander said the institute is educating, on the average, "the best minds among the youth of Brazil who are candidates for the engineering profession; that there is, on the campus, a nucleus of competent, forward-looking academic leadership which welcomes Point Four assistance; that the school has a very high level of prestige in Brazil and a fine tradition, and that the graduates move quickly into positions of responsibility and influence."

He concluded: "In all my long years of teaching, I have never encountered a group of students whose maturity, sense of responsibility, self-discipline and integrity were equal to these qualities of character possessed by the small group of students (here) . . ."

Professor Helander taught mechanical engineering, and was head of the department, at Kansas State from 1935 to 1957. He is the author of numerous engineering papers and has served on committee assignments for several engineering societies.

A graduate of Yeatman High School in St. Louis, Professor Helander earned a bachelor of science degree in mechanical engineering at the University of Illinois in 1915.

Optical Study of Supersonic Boundary-Layer Transition

Microsecond-delay schlieren photographs of supersonic boundary-layer transition taken at the National Bureau of Standards provide definite optical evidence that boundary-layer transition processes in a supersonic air stream are similar to those in a subsonic stream. The photographs were taken using an unusual cylindrical-lens camera designed and constructed at the Bureau.

A Rediscovery

Silicon carbide's discovery in 1891 was an industrial milestone, and a present-day "rediscovery" of the material may be another milestone—this one in solid-state electronics.

Although it is best known as an abrasive, silicon carbide is also a semiconductor that has unusual abilities—it retains its useful electrical characteristics at high temperatures. Research scientists are now using this property to produce rectifiers and transistors that can operate at much higher ambient temperatures than present semiconductor devices. Silicon carbide thus promises to provide lightweight electronic devices for space vehicles, missiles, high-performance aircraft, and other applications where high temperatures are inevitable.

Wires Eliminate Furnace

Engineers have found another use for the wire-mesh reinforcement used in concrete floors—they've made it double as a heating element by connecting it to a power source. Working on the resistance heating principle common in electric toasters, the builders of a North Dakota warehouse were able to eliminate the furnace room and the furnace.

Negative Ion Studies

Studies of the photodetachment of electrons from negative ions are being made at the National Bureau of Standards, with attention directed toward the cross sections of negative atomic and molecular oxygen ions. These interactions are important to studies of ionospheric phenomena and thermodynamic systems involving very hot gases.

Ice Becomes Obsolete

Westinghouse Electric Corporation began production in April of a thermoelectric water cooler—the first thermoelectric home appliance to be manufactured on a production line basis. Designed for use in either homes or offices, the water cooler's refrigeration process comes directly from electricity without the need for a conventional compressor.

Aided by a Sky-Hook

A 200-foot tall steel transmission tower was topped out four days ahead of schedule recently when a Hiller 12E light utility helicopter airlifted 93 feet of the structure in half ton steel sections to within arms reach of riggers.

The entire project, from the 111-foot level until the last insulator was bolted in place, took only 4½ hours of flying time by the 305 horsepower Hiller, which itself weighs only 1,700 pounds.

According to officials of Pacific Power and Light Company, Tyee Construction Co., and Columbia Helicopters, it was the first time a light helicopter had been used to erect a heavy steel structure and the first time an airlift had been used over water in the Pacific Northwest.

Quite A Generating Unit

The largest and most efficient steam-electric generating unit ever built by an investor-owned public utility is in construction at Lawrenceburg, Ind., on the Ohio River, by Indiana & Michigan Electric Company.

This was announced at a joint press conference conducted by Governor Matthew E. Welsh and R. E. Doyle, Jr., vice president and general manager of I & M, a major operating company of the American Electric Power System.

The Governor termed the announcement "a tremendous boost for the economy of southeastern Indiana" and congratulated I & M for the company's "faith in the future growth and prosperity of the Hoosier state."

The 580,000-kilowatt, $73-million unit will be the fourth at I & M's Tanners Creek Plant at Lawrenceburg. Construction began this Summer and is expected to be completed by the Spring of 1964.

Brewing Up Strike

A London shampoo plant using beer as its main raw material touched off a strike by trying to stop its women workers from dipping beer from production vats at tea time. The women returned to work only after management agreed to dispense free beer in the employee's canteen.

Jonah's Wail

PARTY THIRD

By Jonah Jones

Here is the same old story about life with a modern twist. Those who are looking for an aim in life and fun from college should consider the following article. Whether you agree with what will be said or not, this should make you think.

College has trapped the students for another grueling semester. It can be as much of a grind as the students make it. An analysis of a profitable, enjoyable college semester reveals three areas. A quick investigation can give a student the potential of a good future.

First of all one must consider his goal in life. Without a target even the best marksman is worthless. The chosen goal may not be the student's ultimate destination, but he had better believe in it. The fatality rate in engineering is staggering, but there have been students who have made above average grades (3.5 U. of I. grade points or better) and still they change to another field. They believed in engineering enough to do a good job; later they readjusted their sights. Choosing an intermediate goal like this is not an unforgiveable mistake. Just choosing or having someone choose for you a general direction, a direction in which you have no particular interest, is the costly error—in time, money. and reputation. It is enough about goals to say pick a field that you can honestly like and enjoy. You must make this decision yourself.

Many upperclassmen and a few freshmen have their own goal. Now they must find a sure way to get there. The university dictates the necessary courses for any given field, but the number of hours and extra activities are, for the main part, up to the individual. The various intelligence tes (like putting round pegs in squa holes) will give a student son measure of the number of hours he ca handle. This leaves the activity depar ment wide open. If you choose to b a perpetual student, you may learn trade well; but existing to toil only one field could become very tiresom It is more fun, besides being somewh broadening, to enter in some sort of re reation, both mentally and physicall Intramural sports offer the physic exertion and Illini Union or depar mental organizations offer as much d version as man could ask. Try to do worthwhile job in a few activities; yo gain nothing by joining for the sake belonging to everything in sight. O ganizing the various campus activiti and dances, publishing a newspaper magazine, assuming an active role in social fraternity, and working for a pr fessional or hobby club are all time co suming worthwhile pursuits. Choose couple that interest you, and let the be your diversions from study. Wo hard when you work; play hard wh you play.

The third side of the collegiate t angle is social life, known on camp as partying. This is primarily the d version for the weekend since seldo does one find himself in the positi timewise to date during the week.

Few find the happy medium—t proper balance between study, play, a party. The three factors have been pr sented in order of importance. We in school to study. Activities help o learn to get along with others besid being a daily diversion from studi Partying is the weekend enjoyment th forms the third side of college life. R member the order of the numbering a count all three.

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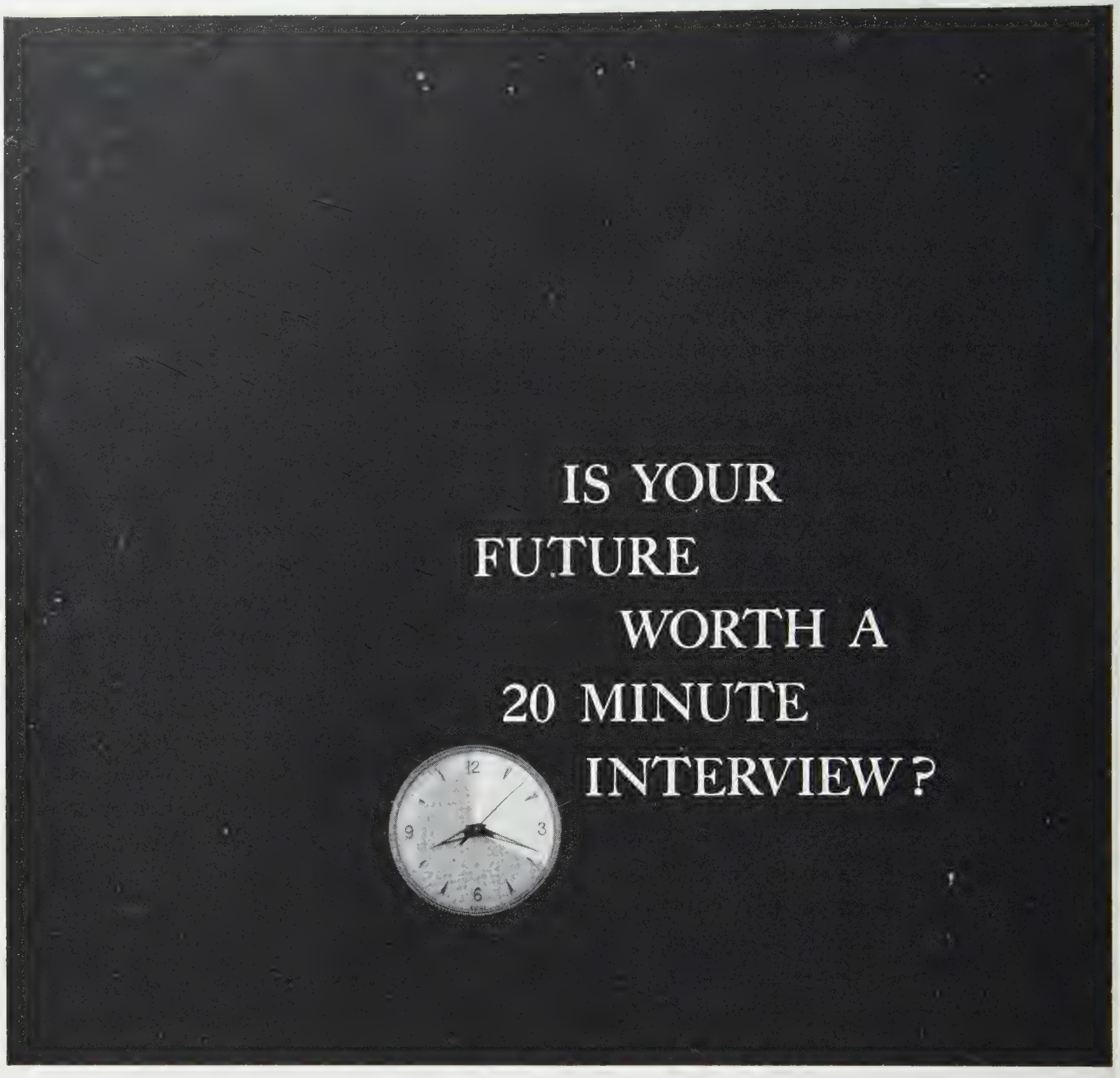

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Manned space flight requires reliable and efficient thermal and atmospheric systems plus secondary power equipment. Complete, integrated systems (such as those pictured above) are under study at Garrett's AiResearch Manufacturing Divisions. Their design reflects 20 years of leadership in airborne and space systems, including NASA's Project Mercury life support system.

Other project areas at Garrett include: solar and nuclear power systems for space applications; electronic systems, including centralized flight data computer systems; and small gas turbines for both military and industrial use.

An orientation program lasting several months in diversified areas is available to every newly-graduated engineer to aid in his placement. It includes working on assignment with experienced engineers in laboratory, preliminary design and development projects.

For further information about a career with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

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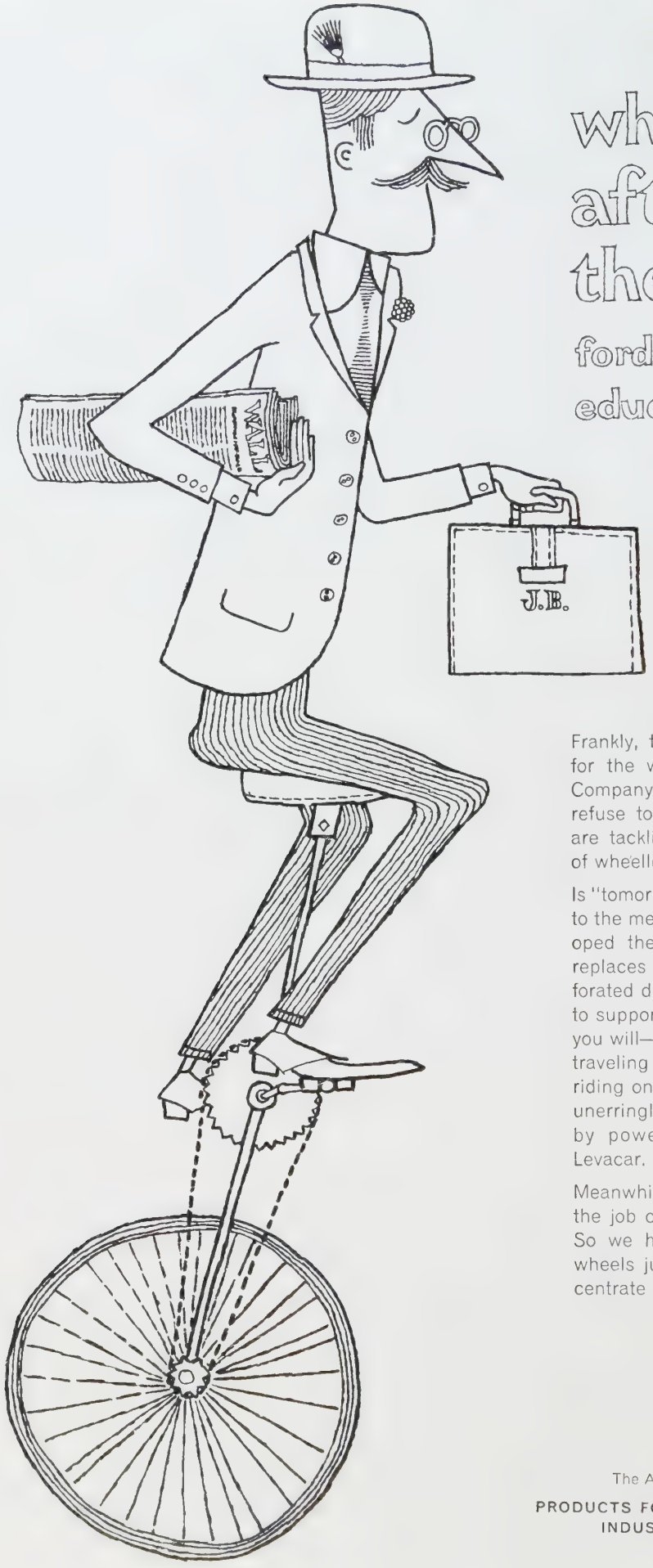

what comes after the wheel?

ford motor company's educated guess

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Is "tomorrow" really far off? Not according to the men at Ford. Already they've developed the Levacar as one possibility. It replaces the wheel with *levapads*, perforated discs which emit powerful air jets to support the vehicle. Air suspension—if you will—of an advanced degree. Imagine traveling swiftly, safely at up to 500 mph, riding on a tissue-thin film of air. Guided unerringly by a system of rails. Propelled by powerful turboprops. This is the Levacar.

Meanwhile we've still got the wheel. And the job of building better cars for today. So we hope you won't mind riding on wheels just a little longer while we concentrate on *both* tasks.

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PTICAL MASERS . . .

(Continued from Page 12)

ve front, and would spread very le. The angular width of the beam radiation should be approximately ratio of the light wave length to the meter of the end plates. Since the velength of the light is short, this is small angle, and the light spread is y small.

aser Construction

A solid-state optical maser can be istructed very simply. Essentially, consists of a rod whose flat ends are ered and whose sides are left open admit the exciting radiation. Recently Bell Laboratories, solid optical mas- using pulsed operation have been istructed. Based on an arrangement posed by T. H. Maiman of the ghes Research Laboratories, scien- s are conducting experiments with y rods about two inches long and -quarter inch in diameter. The de- es have verified many of their pre- ted properties. In particular, opera- n has shown the entire signal output be contained in a very narrow beam. fact, most recent operations have duced a beam with a total spread of s than one-tenth of a degree.

In greatly simplified terms, the gas ser achieves its effect through inter- ions between helium and neon atoms closed in a glass tube about 40 inches g.

The helium atoms are excited to a hly energetic state by a continuous ctrical discharge at radio frequencies. e excited helium atoms transfer their rgy to the neon atoms by colliding th them. The neon atoms, now "stim- ted," radiate this energy—on de- nd—as a highly coherent stream of rared light.

The possible uses of an optical maser ll depend on the characteristics of the lividual device, just as the uses of rious kinds of electron tubes differ. evertheless, it is possible to see some neral uses arising from the basic perties of the device. In communica- n applications, for example, it offers e possibility of extending radio tech- ques to much higher carrier fre- encies. Undoubtedly, higher fre- encies will have advantages and ap- cations not yet envisaged. Some of ese might turn out to be as important the long-distance transmission prop- ties of short-wave radio which were t predicted in advance.

Optical masers would also be par- ularly useful in communication from rth to satellites or space vehicles. For at purpose, their very directional am would permit communication over rge distances with small amounts of wer.

RADIOACTIVE WASTE . . .

(Continued from Page 20)

placed in this hole and then a second pipe is put down and water is forced through it. By doing this, brine is forced out of the other pipe until a cavity is dissolved out of the salt. This cavity will approximate a sphere of 10 to 20 feet in diameter. The experiments have shown very few drawbacks and many advantages. Although these cavities are in salt, there is very little leakage if any and there have been no reported accidents. This process could be carried out on a mass production basis and there are at present many salt beds all over the country.

The radioactive waste disposal could also be accomplished by placing the waste on a rocket to the moon but it would be expensive and could prove hazardous for future moon tourists.[13]

As shown in this report none of the radioactive waste disposal methods in use today are highly reliable and will have to be replaced by better processes. Of the planned methods for the future, the disposal of radioactive waste in salt cavities shows to be the most promising. If experimentation continues and a clean fission process is found, there will be no need for disposal services and the world's problems in this regard will be solved.

1. "Death Dealing Debris," *Newsweek*, 50:96, July 15. 1957.
2. "What Is Safe Waste Disposal?" *Bulletin of Atomic Scientists*. 15:35-43. January 1959.
3. *Webster's New International Dictionary*, G. and C. Merriam Co., 1953.
4. *Bulletin of Atomic Scientists*. January 1959.
5. *Ibid.*
6. *Bulletin of Atomic Scientists*. January 1959.
7. *Newsweek*, July 15, 1957.
8. *Newsweek*, July 15, 1957.
9. "Hot Dumping off Boston," *Nation*, 189:142-3, 144-6, September 19, 1959.
10. "Safety of Waste Disposal into the Sea Questioned," *Scientific News Letter*, 76:382, December 5, 1959.
11. *Bulletin of Atomic Scientists*, January 1959.
12. *Bulletin of Atomic Scientists*, January 1959.

Nature Making Oil

Researchers have concluded, after ten years' study, that "organic action" may be forming petroleum deposits today. Texas A & M scientists found that certain kinds of clay, while settling in ocean beds, absorb animal matter, causing a chemical and physical change of the type that could result in oil "manufacture."

SUSPENSION SYSTEM . . .

(Continued from Page 19)

Here, the locating must be especially precise, for now the steering function is added, but fortunately the driving forces are not present.

Among the front suspension design factors are caster, camber, toe-in, and weight transfer. Roll should be only moderate or the outside wheel in a turn will load up and slide out, depriving the car of its cornering force. The toe-in is fixed at a small degree for stability, the wheels tending to toe-out at speed. Camber is another matter, and may be a bit of a problem. It is the tilt in or out of the top of the wheels, positive if outward, negative if inward, and affects the handling quality. Caster is a result of the mounting of the wheel carrier, and provides, in effect, that the wheels are being pulled forward from in front of their midpoint, thus contributing to their directional stability.

All of these factors, plus a few more, determine the "under-steer" or "over-steer" of a car. Understeer is the condition in which at an increasing speed through a corner, it is necessary to turn the steering farther for the same curve radius. The car plows off the road at the limit, despite the angle of the steered wheels. Oversteer is just the opposite condition, in that at increasing speed, the car tends to follow a spiral inward, the final step being a spin as the rear end comes all the way around. Generally speaking a bit of understeer is preferable, as some oversteering may be provoked at any time by the driver merely standing on the accelerator. As the tires have a certain maximum load which they will sustain, increasing the total load by adding power will cause them to exceed this slightly and begin to slide out sideways.

The factors in the suspension system causing one or the other type of action are well established in the design, but may be altered to a certain extent. As many things may achieve the desired result, a tabulation follows of ways to increase understeer. To add oversteer characteristics, as would be desirable on most American cars, the reverse instructions would hold:

Add weight at the front—or decrease at the rear,

Use softer tires in front—or harder ones at the rear,

Use larger rear tires,

Lower the front roll center—or raise the rear

Increase negative camber at rear—or raise the rear

Add front anti-roll bar—or remove from rear.

Thus the individual may adjust his car's handling to suit himself, though fortunately, most manufacturers realize

(Continued on Page 46)

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THE DEAN'S PAGE . . .

(Continued from Page 16)

Freeport, Senior H.S.—Pashby, R. W., Director of Product Research, Micro Switch, Division of Minneapolis - Honeywell Regulator Co., Freeport EE32.

Galesburg, Senior H.S.—Bohman, Raymond H., 227 W. Losey St., Galesburg, ME43; Daggett, T. E., 1811 McMasters St., Galesburg, EE50.

Glen Ellyn, Township H.S.—Diefenthaler, Robert J., 571 Forest St., Glen Ellyn, EE39; Everitt, Bruce, 26 Muirwood Drive, Glen Ellyn, EE50; Bremner, William C., 616 Oak St., Glen Ellyn, Gen. E.29.

Grayslake, Community H.S. — Inwood, Howard, P.O. Box 77-BB, Route 1, Grayslake, EE33.

Harrisburg, Township H.S.—Bottomley, Arthur, 1305 S. Webster St., Harrisburg, Min.30.

Harvey, Township H.S.—Lefler, Homer M., 301 N. Wolcott St., Thornton, EE42; Zimmerman, J. F., Sinclair Research Laboratories, 400 E. Sibley Blvd., Harvey, ME22-24.

Havana, Community H.S.—Smith, Dorland W., Menard Electric Cooperative 122 S. Sixth St., Petersburg, Ag.E.58.

Highland Park, Senior H.S.—Laegeler, C. J., The Frank C. Hough Co. Libertyville, M.E. 43.

Hinsdale, Senior H.S.—Elder, Clarence, 212 W. Washington St., Room 1301, Chicago 6, EE25, Carlen, Raymond N. 120 N. Clay St., Hinsdale, Met.42.

Homewood, Community H.S.—Forbes, I. G., 934 Bruce Avenue, Flossmoor, CE47.

Hoopeston, Senior H.S.—Childers, Ross E., Canning Machinery Division, Hoopeston, ME58.

Jacksonville, Senior H.S.—Deem, William C., Eli Bridge Company, Jacksonville, ME50.

Joliet, Township H.S.—Sproat, Robert A., 27 South Chicago St., Joliet, CE44; Veale, Jack H., Illinois Clay Products Co., Joliet, Cer.40; Jesberg, Robert O., 112 Eait 15th St., Lockport, ME44.

Knoxville, Senior H.S.—Daggett, T. E., 1811 McMasters St., Galesburg, EE50.

LaGrange, Township H.S.—Aichele, Geo., 4333 Johnson Avenue, Western Springs, EE32.

Libertyville, Libertyville - Fremont H.S.—Schumm, Louis W., Ekco-Alcoa Containers, Inc., Wheeling, CE40.

Lincoln, Community H.S.—Fuller, Kenneth E.. Fuller Seed Co., Lincoln, Ag.E38.

Litchfield, Community H.S.—Koertze, Edward A., 755 Homewood Drive, Indianapolis, Ind., ME58.

Livingston, Community H.S. — Graiff, Leonard B., R. R. No. 1, Box 44, Staunton. ME55.

Lockport, Senior H.S.—Jesberg, Robert O., 112 E. 15th St., Lockport, ME44.

Marion, Community H.S.—Blank H. J. Central Ill. Pub. Serv. Co., Marion, EE50.

McLeansboro, Township H.S.—Holloman, Dale, 212 Meahow Hill Lane, McLeansboro, Min.58.

Midlothian, Township H.S.—Kile, R. W., 17140 Summit Ave.. Hazel Chest, EE49; Veasman, Frank H., Chicago Malleable Castings Co.. 80 E. Jockson Blvd., Chicago 4, CE39.

Moline, Senior H.S.—Nelson, Stanley A., 1741 12th Avenue, Moline, EE35.

Monmouth, Senior H.S.—Shunick, James, 116 E. Boston Avenue, Monmouth, EE34.

Morrison, Community H.S.—Forth, M. W., Products Development Dept., Deere & Co., Moline, Ag.E.48.

Morton, Township H.S.—Rapp, Henry W. Jr., The Morton Pottery Co., Morton, Cer.49.

Mt. Prospect, Senior H.S.—Medal, E.C., 216 S. Louis St., Mt. Prospect.

Mt. Vernon, Senior H.S.—Setzekorn, Kenneth E., Consulting Engineer, Mt. Vernon, CE41.

Murphysboro. Community H.S.—Kupel, Vernon T., 2228 Pine St., Murphysboro.

New Athens, Senior H.S.—Kolditz, L.S., 917 S. Mill St., New Aathens, CE53.

Northbrook, Township H.S. — Randall, Frank Jr., 22 Timber Lane, Northbrook, CE40.

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Park Forest, Township H.S.—Yazell, D. H., 21136 Main St., Matteson, CE47; Bechly, Dan S., 364 Wilshire St., Park Forest, CE43; Skinner, R. E., 9 East Rocket Circle, Park Forest, CE 50.

Peoria, Woodruff H.S.—Stein, Clarence, 305 S. Church St., Washington, ME35.

Peoria Central H.S.—Diemer, Donald P., 1115 North University St., Peoria, Ag.E53.

Peoria Heights, Community H.S.—King, R. J., 4139 Hawthorne Place, Peoria, ME39.

Pinckneyville, Senior H.S.—Halen, L. G., 408 E. Water St., Pinckneyville, Min.34.

Plainеld, Paydon, A. Stephen, R.R. 1, Plainfield, Ag.E40.

Princeton, Township H.S.—Engelbrecht, Louis Bureau County Extension Service, 1019 N. Main St., Princeton, Ag.E51.

Quincy, Senior H.S.—Rouse, Daniel H. Jr., 1315 Broadway, Quincy, ME39.

Riverside, Senior H.S.—Bacon, Louis A., Shaw Metz & Associates, 208 S. LaSalle St., Chicago 4, CE43; Vernetti, John B., Chicago Vitreous Corp., 1425 S. 55th Court, Cicero 50, Cer.38.

Robinson, Central Community H.S.—Maze, Horace J., 1405 N. Robb St., Robinson, ME50.

Rockford, East & West Senior H.S.—Stringer, Robert B., 628 Vale Ave., Rockford, ME47; Anderson, P. A., 5128 Newburg Road, Rockford, CE32.

Roxanna, Senior H.S.—Sprague, S.R., 778 East Woodland, East Alton, ME46.

St. Charles, Senior H.S.—Lamb, Miles, 457 Fullerton Parkway, Chicago 14, Illinois CE40.

Salem, Community H.S.—Roffmann, Harold, 326 E. William St., Salem, CE58.

Shelbyville, Community H.S.—Jedlicka, George R., 825 N. Lodge St., Shelbyville, Ag.E57

Skokie, Township H.S.—Foss, Jack C., 5139 Wright Terrace, Skokie, EE39.

Springfield, Senior H.S.—McCraken, Robert L., 1322 S. Whittier St., Springfield, DSSWV48; Heacock, E. R., 1821 S. Sixth St., Springfield EE32; Broderick, James R., Central Ill. Pub. Serv. Co., Illinois Building, Springfield, EE26; Nelson, Charles A., 126 S. State St., Springfield, CE31.

Staunton, Community H.S.—Graiff, Leonard ., R. R. 1, Box 44, Staunton, ME55.

Streator, Township H.S.—Shaddock, Roland E., 805 S. Bloomington Road, Streator, Ag.E51.

Taylorville, Community H.S. — Eletson, Charles L., Hopper Paper Co., Taylorville, EE50.

Washington, Community H.S.—Kelley, Bruce W., 914 Birchwood Drive, Washington, CE 44.

West Frankfort, Community H.S.—MacDonald, J. W., Old Ben Coal Co., 500 W. Main St., Benton, Min.E22.

Westville, Township H.S.—Freeman, John M., 1624 N. Franklin St., Danville, CE54.

Winnetka, Township H.S.—Marks, Gerald, 2738 Lincoln Lane, Wilmette, EE50 Bulley, Allan E., 1744 W. Armitage Ave Chicago 22, CE18-23.

Woodhull, Alpha-Woodhull H.S.—Daggett, T. E., 1811 McMasters St., Galesburg EE50.

Wood River, Community H.S.—Ryan, J. G., Shell Oil Co., P. O. Box 262, Wood River, Chem.35; Davis, J. W., Shell Oil Co Wood River, ME46; Greenshields, R. J., 55 Whitelaw Ave., Wood River, ME32.

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LaCanada, Calif., General Representative—Harmon, Robert G., 634 Knight Way, La Canada, Calif., CE40.

Milwaukee, Wis., General Representative—Broughton, Dean C., Engineering Mechanics Consultant, A. O. Smith Corporation, P. O. Box 584, Milwaukee 1, Wis ME43.

Shorewood, Wis., General Representative—Stickler, L. E., 2100 E. Kensington Blvd Shorewood 11, Wis., ME45.

Wauwatosa, Wis., General Representative—Murphy, William G., Marquette University, 1515 W. Wisconsin Ave., Milwaukee Wis., CE43.

'Round and 'Round

A test track at the University o Illinois is giving highway materials a much beating in one week as they would get in a year's use on a road.

First result may well be the double barreled one of proving a new low-cost material for secondary roads and city streets and of providing a market for now-useless fly ash piled up by big power plants.

Several industries have provided $66,000 for this research.

The new track is first to include features for thoroughly testing road surface, base, and subgrade under controlled conditions equivalent to those in service.

The track is 25 feet in diameter. It is built on a concrete tank 4½ feet deep so that moisture in the subgrade can be controlled.

Prof. George W. Hollon explains that subgrade drainage is important to highway service. In the test track engineers can have a road with finest drainage possible or one literally floating on water and muck. Either condition and many in between may exist in actual service.

Traffic is supplied by a pair of truck wheels at ends of a steel girder which is pivoted at center of the track. Through motor and shafts the wheels spin around the track, pounding the roadway with the equivalent of 1,000 trucks passing an hour.

BOOK REVIEW

"Engineers in Ivory Towers"

By Cindy Christoffersen, G.E. '65

Robert C. Goodpasture edited material for *Engineers and Ivory Towers* from magazine articles, society papers, transcribed speeches, longhand classroom notes, and graduate lectures of Hardy Cross, Strathcona Professor of Civil Engineering at Yale University. Professor Cross received the Lamme Medal in 1944 from the American Society for Engineering Education ". . . for his development of revolutionary methods of analysis in structural engineering; for his application of these methods to the rigorous training of civil engineers; for his insistence on the great responsibilities of the individual teacher and his scorn of the superficial in education; . . ." But, *Engineers and Ivory Towers* is not a study of the achievements of Hardy Cross in the field of civil engineering. It is a survey of the philosophy he developed toward the profession of engineering and the educating of engineers. His book focuses on the relationship between engineering, scition in engineering and of engineers; the education of engineers; graduate studies and research; concepts of engineering art.

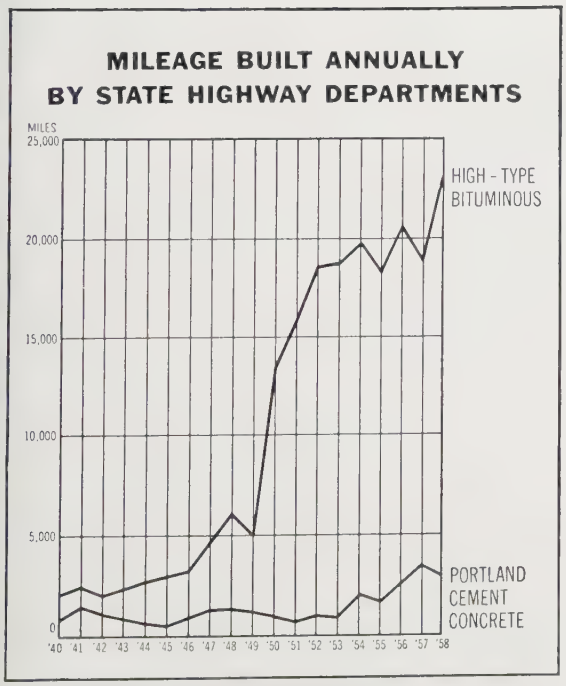
This book explicitly defines intellectual attitudes an engineer should adopt toward his profession. *Engineers and Ivory Towers* contains no technical data, no laboratory reports; however, it might be called a short course in one-up-manship for those students wishing to attain a professional level above mediocracy. Hardy Cross desired that engineers learn to clear their minds and think in simple terms of the natural forces they work with, that they release themselves from intellectual standardization, and that they always work and think in terms of how they are serving humanity. This philosophy is essentially what *Engineers and Ivory Towers* imparts to the engineering student, the professional engineers, and the lay reader.

Written by Hardy Cross, edited by Robert C. Goodpasture. McGraw-Hill Paperback Series, Copyright 1952, 141 pages, $1.50.

Instant Snowless Streets

Philadelphia is considering a proposal that would give parts of the city instant snowless streets. The proposal would require new construction of all large industrial, commercial, apartment and hotel buildings to install radiant heating in sidewalks for automatic snow removal.

Why America's state highway engineers give first choice to Modern High-Type Asphalt Pavement:



SOURCE: U.S. Bureau of Public Roads

The graph on the left shows you that in 1958 *alone* the use of high-type Asphalt pavement increased *618%* over 1940. This is because advances in engineering know-how, in Asphalt technology and in the development of the mechanical paver have made modern, high-type Asphalt pavement the first choice of highway engineers. Its more economical construction and low maintenance costs have saved many millions of tax dollars and kept America's wheels rolling.

Recent engineering advances have developed new, DEEP STRENGTH Asphalt pavement which will provide even better performance and greater pavement economy in the future.

The tax savings possible will amount to millions of dollars and will mean more and better local and interstate roads for our nation.

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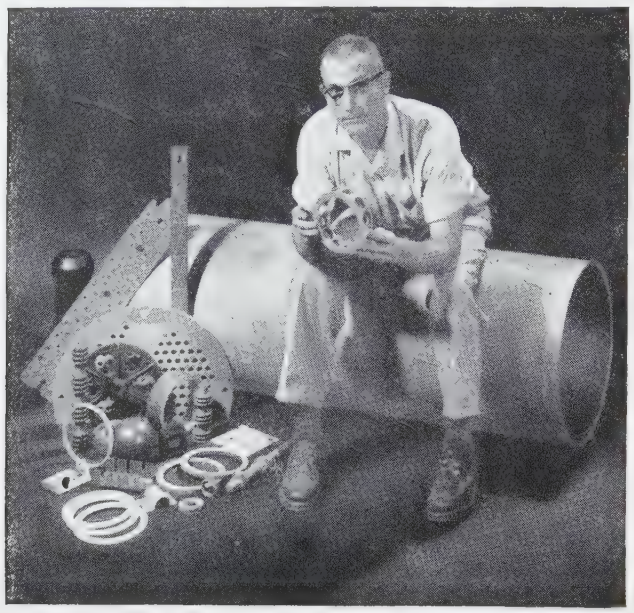

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SUSPENSION SYSTEM . . .

(Continued from Page 41)

the importance of improving roadability, and are working on the problem. An example of this is the fact that be it parallel equal links, unequal wishbones, sliding pillar, or trailing link, everyone now uses the independent front suspension system.

Whatever other improvements or developments in automobiles the future may bring, handling quality is certain to improve. No matter what the speed or time of day, staying out of accidents is the best safety device a car can have, and good suspension systems with improved handling provide just that.

From Heat to Electricity

A new group of high-temperature thermoelectric materials, which permit the direct conversion of heat into electricity at temperatures considerably above the melting point of copper, has been developed by scientists of the Westinghouse Electric Corporation. The new thermoelectric materials are varieties of two compounds, samarium sulfide and cerium sulfide. The new compounds are refractory materials and have excellent high-temperature stability and good thermo-electric efficiencies at temperatures as high as 2,000 degrees Fahrenheit.

New Stainless Steel

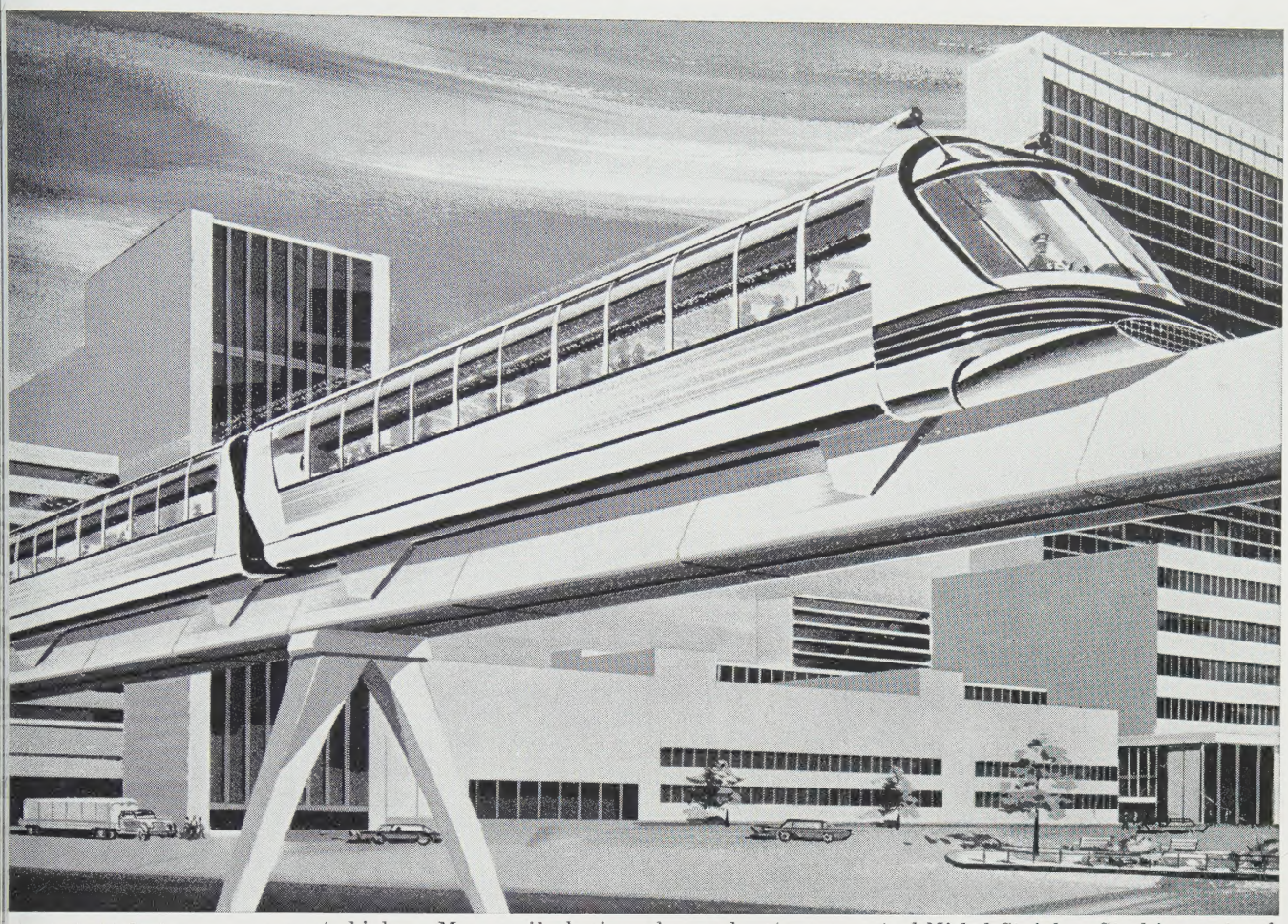
A new and even more corrosion resistant stainless steel has been developed by Allegheny Ludlum Steel Corporation after two years of intensive development work. It is expected that the new alloy will be used initially in the automotive industry for which it was developed, W. B. Pierce, vice president of sales for the steel firm, said.

It is expected that while the automotive industry will be the first to utilize this new corrosion resistant stainless steel, other industries, notably in the architectural field and the furniture and appliance fields, will also be interested in the new material.

Sola Joins Ford

Samuel L. Sola, former assistant to the chief of Mechanical Systems Engineering at Nortronics Division of Northrop Corporation, has joined Aeronutronic Division of Ford Motor Company as manager of Automotive Design for Automotive Electronic Equipment Operations.

He received a B.S. degree in Mechanical Engineering from the University of Illinois in 1941 and a Master of Engineering degree from the University of California at Los Angeles in 1958.



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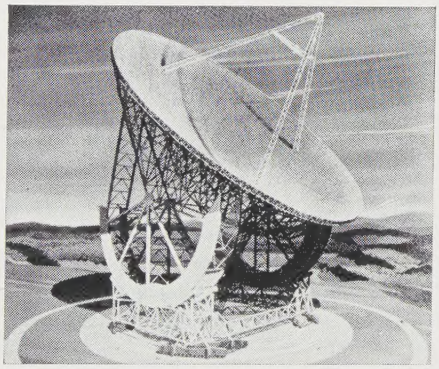
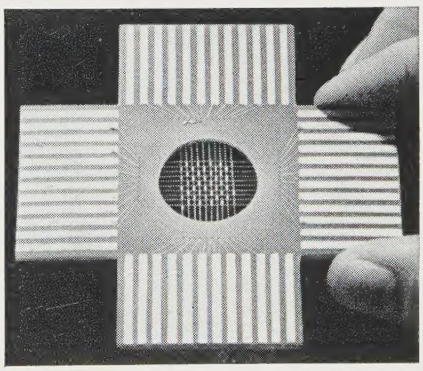


38 billion light years — that's how far this 66-story telescope can "see" into space. Nickel in steel gave engineers a material tough enough to maintain precision in the rotating mechanism even with anticipated 20,000 ton load. Nickel used in steel members provided high strength at minimum weight to support the giant reflector.



Magnetic memory. This tiny part takes advantage of the unusual magnetic behavior of a twisted high-nickel alloy wire. Interwoven wire can store thousands of "bits" of information magnetically, ready to answer the computer's call. When twisted, this high-nickel alloy shifts magnetization direction from longitudinal to a helical path.

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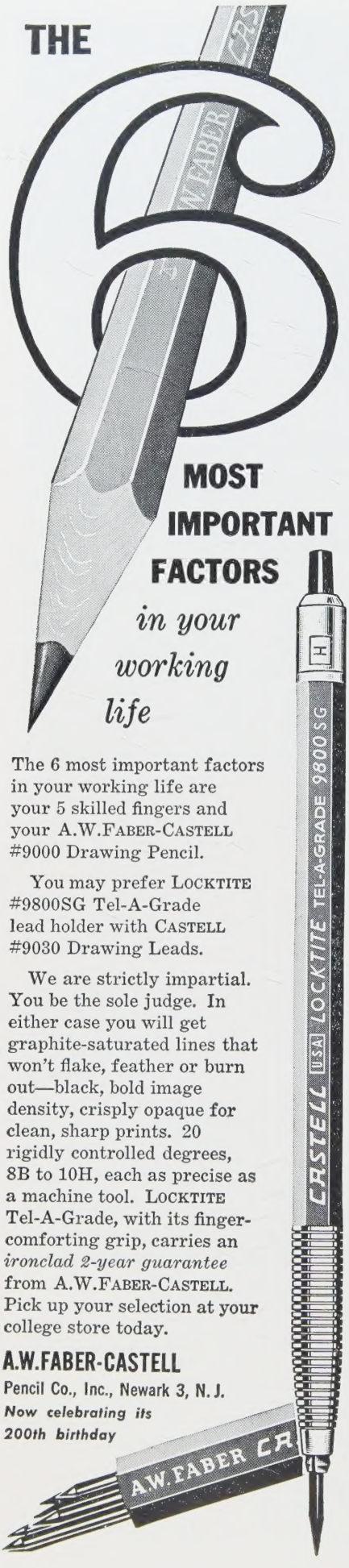

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AIRCRAFT WARNING . . .

(Continued from Page 28)

clean photo cells, because dust can cause alarm in some cases.

In the short history of aviation, air to air refueling has assumed an important position. During the 1920's and 30's, many endurance flights were undertaken to prove the durability of the airplane and the pilot. To carry out these endurance flights, methods had to be devised to refuel the airplane in flight. In some of these flights, fuel was snatched from automobiles speeding down the runway; hauled up in cans to the airplane above and poured into the tank. Later they refueled through a dangling hose from an airplane above. It was a dangerous and tiring process.

During the second world war, and with the advent of the jet type aircraft and their high rate of fuel consumption, air to air refueling has become more and more important. For a jet to take off with maximum pay load or bomb load and still get maximum range, it is necessary that it be refueled in flight. As an example, it takes a B-47, 600 gallons of fuel to warm up and taxi into take off position. You have read of non-stop flights around the world. This was accomplished by air to air refueling at several points around the world. Later headlines tell of large jet bombers and jet interceptors flying two or three times their normal range by air to air refueling.

Two methods of connecting the tanker to the receiver were developed, and are still in use; the probe and the flying boom. The British were instrumental in the development of the probe. By this method a hollow probe is dangled behind the tanker; the receiver airplane is actually flown into the probe so that the probe spears the receiver. The flying boom is used by the USAF. It is a telescoping boom extending from the tanker. Its position, within limits, is controlled by the boom operator by the use of controllable fins called rudavators. When the tanker and the receiver are in proper position, the boom operator literally flies the boom into position and then extends it into the refueling receptacle.

At this time an air to air refueling schematic will be explained. Now that the plane is refueled it can fly to the destination with an atomic payload. The target is approached; the word comes to open the bomb bay doors. When the doors are opened a green light goes on indicating a safe condition. It would be a mistake to drop an atomic bomb through the doors, however, warning and control circuits prevent this.

Landing

As an approach to the field is ma
it would be a good feeling to know t
the landing gear is down and lock
retarded, a warning is received au
matically from the landing gear wa
ing system.

If the hydraulic system is not fu
tioning, the gear can be cranked do
in some cases. Sometimes wheel-
landings are attempted. Pilot eject
is another alternative. As the pilot flo
down he might remember that he f
got to test the light, and the o
thing wrong was a burned out bu

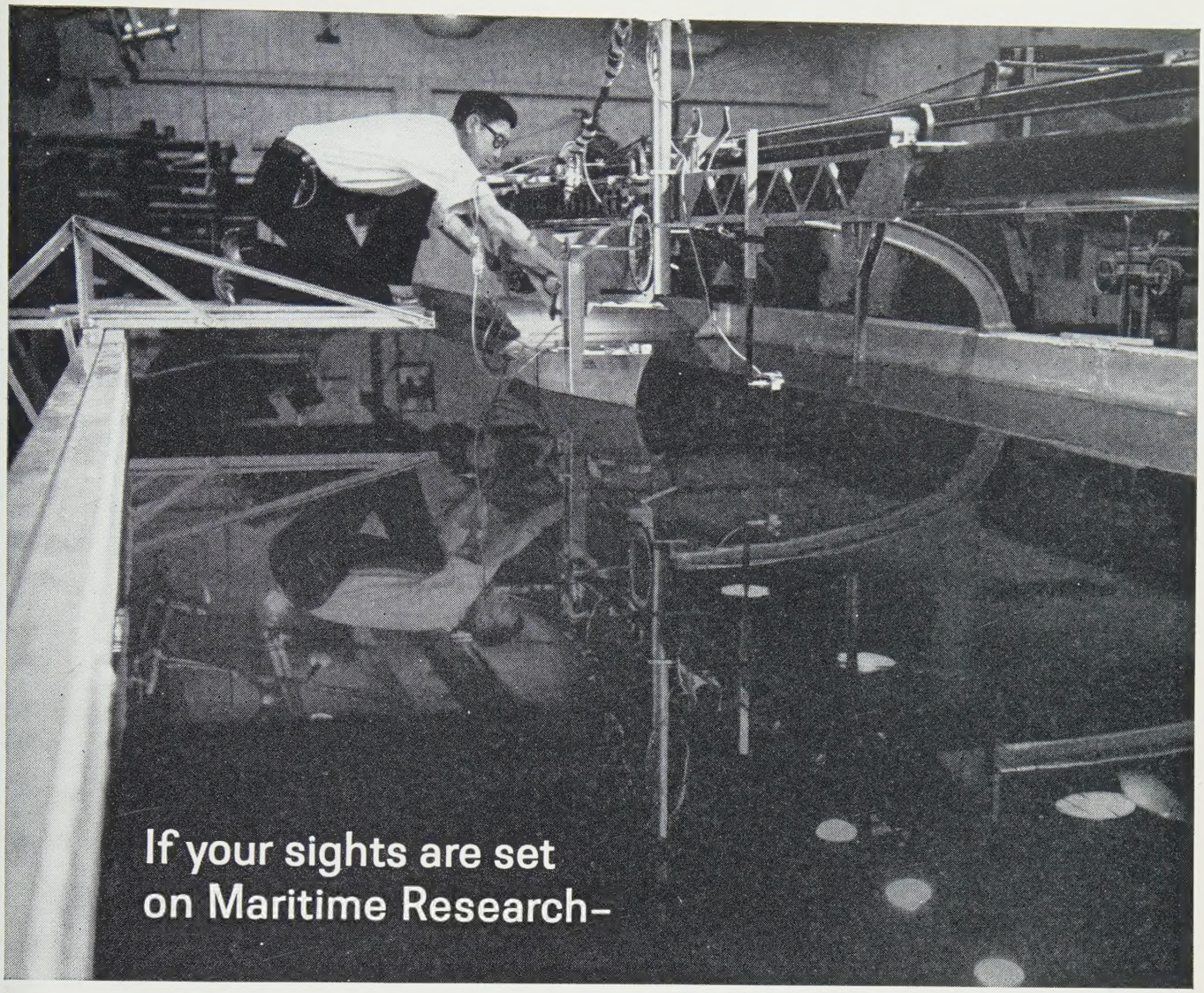
The final system of interest is
anti-skid system. Since there is no fe
back of feel when the wheels are sk
ding, there is the possibility of exc
skidding and eventual blow out. W
the bicycle landing gears, made nec
sary by the thin wing design on sc
aircraft, it is impossible to detect a s
condition. Because of this reason, am
others, the anti-skid system was
ve'oped. It has been proven by test t
the greatest breaking power is just
fore a skid occurs. The tires heat
and the Coefficient of friction g
down .1 in 30 defrees F. Another c
cept is that as the rubber comes
the tire, it forms little balls and
as a series of rollers. The anti-skid
tem provides a pumping effect, not p
sible by human reaction, because hur
reaction time to release the brakes
ceeds the duration of the incipient s

This system has shown a marked
duction of about 30 percent less lan
distance. As the brakes are first app
lower pressure is used and as the sp
of the wheel decreases a higher p
sure is given by means of a press
modulator.

A runway test on a wet runway
performed with the following resul

First a landing was made with
airplane equipped with the anti-
system, the airplane being 12 per
over weight for landing. Brakes w
applied at 1200 psi, and a landing sp
of 80 to 85 knots. The landing dista
was 1200 yards. The tires had
marks on them. In an identical
with the same load conditions, g
difficulty was encountered without
system. It took 1600 yards to stop,
ing a breaking chute. The landing s
was 70 knots, still two tires were bl
and the six remaining were dama
beyond repair. In conclusion it ca
said that in general, this system
creases a 2000 yard runway by
yards.

In conclusion, engineers have
keeping our aircraft up with safety
vices of all conceivable shapes
forms. New devices are conceived e
day. But with the too numerous
incidences every year, it is obvious
ultimate goal has not been reached



Technician preparing for motion-picture studies of a model in the testing tank at Stevens Institute of Technology.

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Interview with General Electric's Dr. J. H. Hollomon

Manager—General Engineering Laboratory

Society Has New Needs and Wants—Plan Your Career Accordingly

DR. HOLLOMON is responsible for General Electric's centralized, advanced engineering activities. He is also an adjunct professor of metallurgy at RPI, serves in advisory posts for four universities, and is a member of the Technical Assistance panel of President Kennedy's Scientific Advisory Committee. Long interested in emphasizing new areas of opportunity for engineers and scientists, the following highlights some of Dr. Hollomon's opinions.

Q. Dr. Hollomon, what characterizes the new needs and wants of society?

A. There are four significant changes in recent times that characterize these needs and wants.

1. The increases in the number of people who live in cities: the accompanying need is for adequate control of air pollution, elimination of transportation bottlenecks, slum clearance, and adequate water resources.

2. The shift in our economy from agriculture and manufacturing to "services": today less than half our working population produces the food and goods for the remainder. Education, health, and recreation are new needs. They require a new information technology to eliminate the drudgery of routine mental tasks as our electrical technology eliminated routine physical drudgery.

3. The continued need for national defense and for arms reduction: the majority of our technical resources is concerned with research and development for military purposes. But increasingly, we must look to new technical means for detection and control.

4. The arising expectations of the peoples of the newly developing nations: here the "haves" of our society must provide the industry and the tools for the "have-nots" of the new countries if they are to share the advantages of modern technology. It is now clearly recognized by all that Western technology is capable of furnishing the material goods of modern life to the billions of people of the world rather than only to the millions in the West.

We see in these new wants, prospects for General Electric's future growth and contribution.

Q. Could you give us some examples?

A. We are investigating techniques for the control and measurement of air and water pollution which will be applicable not only to cities, but to individual households. We have developed, for example, new methods of purifying salt water and specific techniques for determining impurities in polluted air. General Electric is increasing its international business by furnishing power generating and transportation equipment for Africa, South America, and Southern Asia.

We are looking for other products that would be helpful to these areas to develop their economy and to improve their way of life. We can develop new information systems, new ways of storing and retrieving information, or handling it in computers. We can design new devices that do some of the thinking functions of men, that will make education more effective and perhaps contribute substantially to reducing the cost of medical treatment. We can design new devices for more efficient "paper handling" in the service industries.

Q. If I want to be a part of this new activity, how should I plan my career?

A. First of all, recognize that the meeting of needs and wants of society with products and services is most important and satisfying work. Today this activity requires not only knowledge of science and technology but also of economics, sociology and the best of the past as learned from the liberal arts. To do the engineering involved requires, at least for young men, the most varied experience possible. This means working at a number of different jobs involving different science and technology and different products. This kind of experience for engineers is one of the best means of learning how to conceive and design —how to be able to meet the changing requirements of the times.

For scientists, look to those new fields in biology, biophysics, information, and power generation that afford the most challenge in understanding the world in which we live.

But above all else, the science explosion of the last several decades means that the tools you will use as an engineer or as a scientist and the knowledge involved will change during your lifetime. Thus, you must be in a position to continue your education, either on your own or in courses at universities or in special courses sponsored by the company for which you work.

Q. Does General Electric offer these advantages to a young scientist or engineer?

A. General Electric is a large diversified company in which young men have the opportunity of working on a variety of problems with experienced people at the forefront of science and technology. There are a number of laboratories where research and advanced development is and has been traditional. The Company offers incentives for graduate studies, as well as a number of educational programs with expert and experienced teachers. Talk to your placement officers and members of your faculty. I hope you will plan to meet our representative when he visits the campus.

A recent address by Dr. Hollomon entitled "Engineering's Great Challenge — the 1960's," will be of interest to most Juniors, Seniors, and Graduate Students. It's available by addressing your request to: Dr. J. H. Hollomon, Section 699-2, General Electric Company, Schenectady 5, N.Y.

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